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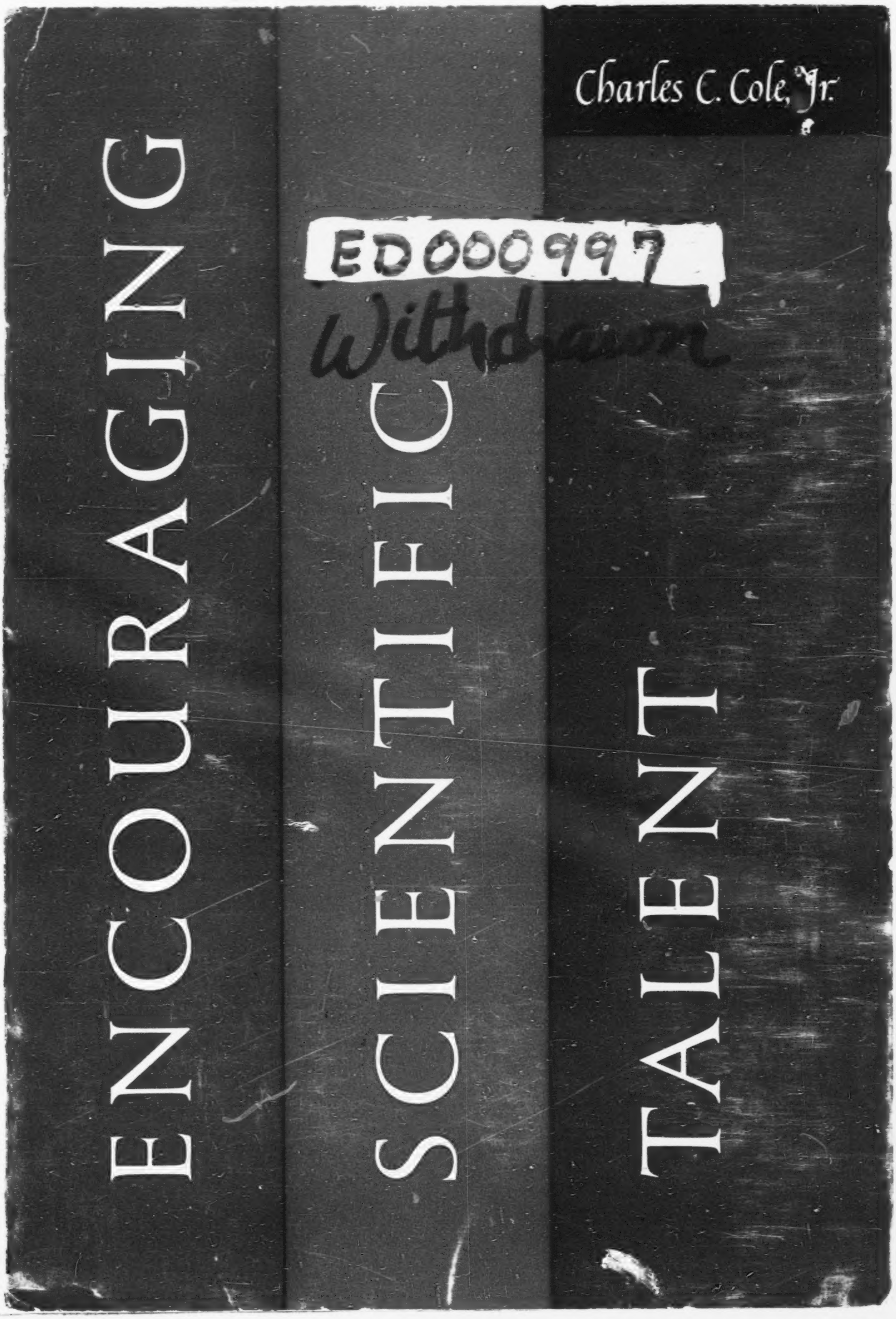

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ENCOURAGING SCIENTIFIC TALENT

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ENCOURAGING SCIENTIFIC TALENT

A study of America's able students who are lost to college and of ways of attracting them to college and science careers

by Charles C. Cole, Jr.

COLLEGE ENTRANCE EXAMINATION BOARD, NEW YORK, 1956

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Preface

This is the report of a study of the loss of talented persons from high school to college and of ways to encourage those with high-level ability, particularly those with scientific talent, to enter institutions of higher education and to follow science careers. Our objectives have been to bring together relevant information from all available sources on the nature of scientific ability, its supply and demand, and the factors encouraging or discouraging the production of scientists; to evaluate estimates of this loss of students from high school to college with an analysis of the factors influencing college-going among different groups in the population; and to consider various means by which more capable persons might be attracted to college and to science careers.

This study was conducted at the instance and with the support of the National Science Foundation under contract with the College Entrance Examination Board. Although somewhat abbreviated, the chapters in this volume are essentially the same as those submitted in the final report to the National Science Foundation in June, 1955. Dr. Alan T. Waterman, director of the Foundation, Dr. Harry C. Kelly, assistant director for scientific personnel and education, and Dr. Bowen C. Dees, program director for fellowships, were instrumental in the study's inception. However, the opinions expressed and the conclusions reached in this report do not necessarily represent the views of the National Science Foundation or of the College Board.

The most significant original research undertaken as part of this project was the National Study of High School Students and Their Plans, in which a questionnaire was administered in connection with an aptitude test to a nation-wide sample of public high school seniors and sophomores. The survey was conducted and tabulated by the Educational Testing Service. Its results, reported in the section bearing the study's title, fill an important need for current nation-wide figures on high school seniors' college plans, interest in science, and attitudes toward scholarships.

In planning the study, we attempted to bridge the gaps between disciplines by bringing together data from many academic specializations. In writing the report, we have constantly striven to separate questions of fact and opinion, and to maintain complete objectivity in presenting our findings and other evidence relevant to the study. As has often been pointed out, however, the very evidence selected may in itself reflect a particular point of view. In passages where opinion is presented in this report an attempt has been made to express the collective opinion of educators and other specialists and not simply personal whim.

I am deeply grateful to all those individuals in education, industry, and government who had a special ability or interest in some aspect of this project and who gave so freely of their time and advice. I am particularly indebted to those experts who wrote memoranda for this project which have been most helpful to me in writing this volume. They are: Mrs. Jane Blizard of the New England Institute for Medical Research for her memorandum on "Increasing the Effective Number of Women in Science"; Dr. Paul Brandwein of the Forest Hills, New York, High School, whose memorandum on high school science teaching appears as a chapter in his book, *The Gifted Student as Future Scientist;* Professor Herbert A. Deane of Columbia University, whose analysis of political science in the United States appears as Appendix B; Professor Robert J. Havighurst of the University of Chicago, whose concept of motivation and estimates of the loss of able students from high school to college have been published in the American Council on Education's booklet, *Approaching Equality of Opportunity in Higher Education;* Mrs. Allaire U. Karzon of the law firm of Hodgson, Russ, Andrews, Woods, and Goodyear of Buffalo, New York, whose proposals for broader child-care tax deductions to encourage more women into scientific careers appears as Appendix A.

Grateful thanks are also due to Glen Stice, Warren Torgerson, and William G. Mollenkopf of the Educational Testing Service for planning and carrying out the National Study of High School Students and Their Plans. Mr. Wesley W. Walton, director of the Sponsored Scholarship Service of Educational Testing Service, also provided invaluable assistance. I am also grateful to Stephen Viederman and Solomon Robinson, two Columbia College students who as research assistants were particularly helpful.

It was also a great help to have the assistance of an Advisory Committee which met twice during the year to review the approach, methods, and results of the project and to criticize the manuscript. The members of the Advisory Committee were Samuel T. Arnold, provost of Brown University, Chairman; C. W. deKiewiet, president of the University of Rochester; John R. Dunning, dean of the School of Engineering, Columbia University; Raymond

F. Howes, staff associate of the American Council on Education; Esther Lloyd-Jones, professor of education at Teachers College, Columbia University; Lloyd S. Michael, principal of the Evanston Township High School; Reverend Paul C. Reinert, president of Saint Louis University; John M. Stalnaker, president of the National Merit Scholarship Corporation; Foster Strong, dean of freshmen at the California Institute of Technology; and Dael Wolfle, executive secretary of the American Association for the Advancement of Science. Throughout this study the encouragement, confidence, and advice of Frank H. Bowles and William C. Fels of the College Entrance Examination Board were instrumental in the emergence of a final report. Gene R. Hawes of the College Board staff has been in charge of the production of this volume. I am grateful for the experience of working at such a crucial, challenging task.

CHARLES C. COLE, JR., *Assistant Dean*
Columbia College
Columbia University

April 2, 1956

Introduction: Science and scientists

No other word is perhaps so characteristic of twentieth-century civilization as science. No other sphere of activity is so important in our time to our advancement in peace, our survival in war. Few serious questions seem to occupy as much attention, to be so glamorized, defended and despised, revered, and misunderstood as the role of science and scientists in our society. In an atomic era when world-shaking inventions and amazingly complex research daily transform our lives, science affects all men. The welfare of science has become a common concern; its fate and the destiny of our civilization appear synonymous. Any depletion in the ranks of science is a debit all society must record. Any substantial waste of scientific talent can do our society irreparable harm.

What is science? What are the sciences? To what extent has our conception of the word changed over the years? Science, in its original sense, meant knowledge, to know. In more recent times it has referred to a particular kind of systematized knowledge accumulated by certain quantitative methods and related to the operation of recognizable universal laws. As more knowledge has accumulated, as methods improved and tools of measurement were refined, and as more so-called laws became identifiable, the word science has seemed to expand, embracing more and more subject matter.

Perhaps it is more accurate to speak of the sciences for there is no longer one scientific discipline but many. The most precise of them all, and therefore to many the most scientific, are the mathematical sciences utilizing a kind of logical analysis and a vocabulary of symbols to test theorems and check hypotheses. The symbols and formulae of mathematics serve the other sciences but are an entity without them. Closely allied are the physical sciences dealing with the laws of inanimate nature, examining the principles universal to things as small as an atom, as large as a star. It is the physical sciences that frequently come to mind when one speaks of science for out of this area have come the most spectacular advances since the seventeenth century. The subject matter of physics, chemistry, and astronomy are more clearly embedded in the public mind as characteristic of science. The laws of motion, thermodynamics, carbon linkage, photosynthesis, laws of gases, gravitation, and spectrum analysis—these are familiar mysteries to the layman who thinks of the natural sciences as the only science worth the name. But the sciences dealing with living things, biology and certain divisions of psychology, some would add, are also "scientific." However, although experimentation and the discovery of laws are part and parcel of their trade, the biological sciences are considered more descriptive than the physical sciences which, dealing with non-living things, have reached a stage of greater certainty in their development.

Another division, the social sciences, is even farther removed from the pinnacle of precision characterizing the mathematical sciences. The social sciences, still at a much earlier stage of development, deal with the behavior of individuals and groups. Less certainty, poorer prediction, and practically no experimental control characterize the study of social psychology, sociology, anthropology, economics, political science, and history. Characterized by different methodologies, a less precise vocabulary, and more subjectivity than the natural sciences, the social sciences do not have the stature or prestige in the eyes of the public enjoyed by physics, chemistry, or mathematics.

Other disciplines, such as the medical sciences, agricultural sciences, and engineering sciences, are also identifiable. In our technological society, the engineering sciences are emerging in a new light. Based on the application of physical laws to everyday practice in industrial and social activity, the engineering sciences have a practical orientation recognized and valued by non-scientists. The purpose of the engineering sciences is, in the words of Harold G. Moulton, "to apply the new knowledge that is continuously accumulating to the improvement of productive instruments and processes, with a view to increasing the efficiency of mankind in adapting natural resources to the satisfaction of human wants."[1] Concerned with making matter and power useful to man, the engineering sciences have become more and more diversified as our industrialization has matured. Now consisting of over 57 different branches, engineering is concerned with "applying science in an economic manner to the needs of mankind in its broad field," according to Vannevar Bush.[2]

In all these types of sciences there is what we can call scientific doctrine, frequently established through experimentation, which rests on laws and theories. Some of the laws are descriptive, some quantitative. Some of the theories are ironclad and age-old, others await the instruments and experiments to validate them. What unity exists among the sciences can be seen in their effort to explain, to systematize, to comprehend the universe.

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[1] Moulton in Thornton, *Science and Social Change*, p. 474.

[2] Bush, *Endless Horizons*, p. 137.

Other definitions may serve to clarify the term. Science has been called an exploration by James B. Conant and an attitude of mind by H. A. Spoehr and John C. Merriam; it has been described as an integral part of man's whole life by Warren Weaver, who has pictured it as an activity which is a "blend of logic, intuition, art, and belief."[3] Condon's definition is more specific. He calls science a "systematic study of natural phenomena by rationally planned experimentation and rational analysis of the results . . . the most powerful method known to man for gaining knowledge about the world in which he lives."[4]

While science does not know all things and does not fully understand those things which it does know, while it is limited in what new mysteries it can unfold in the atom and the gene, the sun's rays or the Antarctic's cold, science has amassed an overwhelming amount of information, an impressive array of laws, theories, and hypotheses. Science rests on an important assumption that certain accurate information can be learned and applied in human endeavor and that certain fundamental rules universally hold regardless of time or place. Although no longer as self-confident as Helmholtz, Pearson, and other nineteenth-century figures were in assuming the infinite extension of science and the scientific method to all walks of life, the scientist of the twentieth century still sees in his expanding subject a dependable effort to find out how the universe works.

One aspect of science that is frequently overlooked is its dynamic characteristic. As a discipline it is not static. Its laws, its findings, and the raw material of its investigations are ever accumulating. It is constantly growing in the body of information it embraces, in its methodology, in the conclusions it is able to reach. And the speed of its growth seems to be ever increasing. After centuries of relative insignificance, science started to expand in scope and significance with the great discoveries and innovations of the seventeenth century in Europe. Its status as a profession in this country is of even more recent origin. It is well to remember, as Conant and others have pointed out, that some of the early contributions to the development of physics and chemistry were made by amateurs. By the middle of the nineteenth century, what had been called natural philosophy in academic circles emerged as a recognized profession. In 1847 the first school of science in the United States was established at Harvard but it was not until after 1880 that professional scientists were found in some numbers. Even so, as late as 1900 there were no industrial research laboratories in the country. The now-familiar contributions to modern science by Einstein, Mach, and others brought to an end the hold over the profession of the Newtonian mechanistic approach and liberated scholars from the observational, classificatory school of thought. Aided by an accelerated industrialization, catalyzed by two world wars, science in the twentieth century has mushroomed in size, influence, and complexity.

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[3] Weaver, "Fundamental Questions in Science." *Scientific American,* vol. 189, Sept., 1953, p. 51.

[4] Condon, "Science, Secrecy, Security," *Harper's,* vol. 200, Feb., 1950, p. 58; see also Thornton, *Science and Social Change,* p. 19, 114, 120, 554; Campbell, *What is Science?*

With the number of discoveries increasing in geometric progression, with new elements being uncovered and produced, with new formulae, techniques, and experiments to be learned, the absolute essential minimum that must be known in a subject increases every year. And with increasing complexity and diversity, the scientific disciplines have subdivided again and again, and each requires more and more formalized training all the time. In the words of A. W. Haslett, "In every branch of science it is almost a life-work to keep abreast of all that other people are doing and thinking even in one small subsection of the whole. And the mere mechanical distribution of information to all who may be concerned has become in itself quite a major problem."[5]

This dynamic quality in science is bound to continue. New scientific subdivisions and new perfections in methodologies will open new vistas. Just as biochemistry and geophysics have emerged in recent times, just as sociometrics and social physics loom on the horizon, so too will other scientific disciplines emerge. Perhaps Karl Pearson was more prophetic than we are willing to admit when he wrote, "The field of science is unlimited; its solid contents are endless; every group of phenomena, every phase of social life, every stage of past or present development is material for science."[6]

Another characteristic of science, as provocative as its dynamic trait, is its human element. After all, science is the subject studied by scientists just as scientists are those who study science. It was Einstein himself who pointed out that the fundamental concepts of science are "free inventions of the human intellect."[7] Science is not an impersonal subject consisting of accumulated facts with no reference to the human and his intellect or values but a discipline in which the human being, working in what Conant has pictured as impartial and unprejudiced inquiry, hammers out concepts and theoretical knowledge. Years ago Norman Campbell seemed to be suggesting this human element when he wrote, "Science is the study of those judgments concerning which universal agreement can be obtained."[8] More recently A. H. Maslow has propounded a view of science which emphasizes its reliance on human values, which stresses its relationship not only to the reality discovered but also to the human being doing the discovering.[9]

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[5] Haslett, *Science in Transition*, p. 199.
[6] Pearson, *The Grammar of Science*, p. 12.
[7] Quoted in Northrop, *The Logic of the Sciences and the Humanities*, p. 123.

The human element is apparent in considering what are the scientific methods. This term must be plural for there is clearly no single scientific method. Indeed, the methods known as scientific are still in their infancy; as René Dubos has pointed out, "We understand only the most obvious and pedestrian components."[10] There is little that need be added here to the wealth of profound observation made by Conant, Northrop, and others on this subject. Rather than re-listing the subtly different methodological emphases in the approaches of Bacon, Descartes, Morris Cohen and Nagel, and others which, after all, are relative to the discipline's evolution, it should suffice our purpose to identify in the scientific methods the following ingredients: a continuous questioning, an insistence on accuracy, a patient assemblage of quantifiable information, a bold hypothesizing that submits to verification, a consistency that strives for universality, an abstractness that struggles for clarity and simplicity, an open mind that demands intellectual honesty, and a precision-oriented reasoning that searches for ever-widening generalizations. Whether one agrees with Pasteur, who said the scientific methods consisted of "systematic observation, experiment, and reasoning"; with Counts, who summed them up as the "method of intelligence"[11]; or with P. W. Bridgman's facile phrase, "doing one's damnedest with one's mind, no holds barred,"[12] does not really matter. What is important seems to be that there is no simple, step-by-step procedure developed over a certain period of time into one authoritatively accepted "scientific method." Indeed, the sudden inspiration, the hunch, the aimless experimenting that characterizes some research frequently is more productive than the careful step-by-step techniques more popularly associated in the public mind with what the scientist is supposed to do. The indirect approach is just as useful in scientific as it is in military strategy.

In speaking of scientific methods it is also well to bear in mind the importance in all sciences of fundamental, or pure, research as against applied research. At the present time, experimentation for a particular purpose, for development of new weapons, and for military research projects frequently represents the popular conception of what scientific research is. Important and extensive though applied research is today, overemphasis on it curtails the fundamental research that is the life-blood of scientific activity. To be most productive scientific research must range over wide vistas; to be most effective it must be "impractical," have no immediate end in view. Basic research is an uncertain, unpredictable operation which may or may not result in technological development, a new weapon, or a new concept of the universe. Out of the basic research of Faraday came electrical industries; out of the impractical investigations of Hertz and Maxwell came the radio. But out of other pure research efforts have come less spectacular results. Indeed, there is a certain artificiality in separating what is fundamental from what is applied.[13]

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[8] Campbell, *What is Science?*, p. 27.

[9] Maslow, *Motivation and Personality*, p. 1.

[10] Dubos in Cohen, I. and Watson (eds.), *General Education in Science*, p. 13. For stimulating discussions of the scientific methods see Northrop, *The Logic of the Sciences and the Humanities;* Thornton (ed.), *Science and Social Change;* Conant, *Science and Common Sense;* Haslett, *Science in Transition;* Cohen, M., *American Thought.*

[11] Counts, *Education and American Civilization*, p. 248.

[12] Bridgman, "The Prospect for Intelligence," *Yale Review*, vol. 34, spring, 1945, p. 450.

An examination of the literature of science and the scientific methods suggests several implications for our search for scientific talent. First, science has become so important to society, has contributed so much to the material enhancement of living, that society is now dependent on science as it has never been before. Science dominates our civilization and there is reason to believe that future developments in that civilization and in science itself are limited primarily by the number of persons with ability and training who enter science fields. Second, as H. A. Spoehr has suggested, modern man has tended to take this future advance of science for granted but each new discovery requires greater preparation, deeper insight, and vaster knowledge.[14] In a sense, what we need today is not less but more science and more persons who are scientifically literate. The scientific methods need not be the preserve of a few who operate cyclotrons.

In addition, it is a mistake to place primary emphasis on techniques when examining science and the scientific methods. Its true power lies in an attitude of mind, a faith in the essential order and lawfulness of the universe, and a reliance on man's rational objectivity. Perhaps George Counts is correct in calling science, "The greatest single force moving in and shaping the modern age . . . the most profound expression of the humanistic spirit."[15]

Furthermore, scientific endeavor appears to be more and more a cooperative venture. The single scientist working alone is being replaced by inter-disciplinary research teams and group efforts. New demands on training, personality, and productivity will be inevitable. Finally, just as science has changed in meaning and direction in the past, so too will it continue to expand and move in new directions. Refinements in methodology, new frontiers for exploration, and new disciplines are sure to emerge. John Dewey used to speak of the scientific revolution still to come. George W. Gray has reminded us that

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[13] See, for instance, Appleton, "Science, Industry, and Government," *Technology Review*, vol. 49, Feb., 1947, p. 244.

[14] Spoehr, "Society in the Grip of Science," *Impact of Science on Society*, vol. IV, no. 1 (spring, 1953), p. 3.

[15] Counts, *Education and American Civilization*, p. 244.

"what we know may be as only a few shells picked from the shore when compared with the vast sea of our ignorance, but what we know is colossal compared with the knowledge we have put to use."[16] We are only on the threshold.

One direction in which some think science may some day make its most impressive gains is in the area of the social sciences. Although this area of human knowledge has emerged as worthy of scientific study, the social sciences have not yet reached the stage where they are considered, by either educators or the public, in the same category with physics or chemistry. The scope of the social sciences is not as clearly defined, there are limits to its methodology and findings, there are flaws in its experimental controls. Nowhere can man apply the conclusions of the social sciences with the same universal certainty, nor is there the same cumulative advance from subject to subject, from experiment to experiment, that we frequently observe in the natural sciences. At the same time, there have developed clearly defined disciplines, such as anthropology, psychology, human geography, economics, political economy, sociology, and history, which employ careful methods and have reference to some universal concepts which cannot be ignored.[17] Statistical methods are being employed more and more fruitfully in studying social phenomena. As John Q. Stewart has put it:

> "There are journals of econometrics, sociometrics, psychometrics. Quantitative studies are accepted in philology. There are inductive and deductive studies of the process of learning: communication theory, created principally by telephone engineers but initiated by Francis Bacon for the visual semaphores of the early seventeenth century, ties in with the expanding art of data reduction and automatic computation . . . . The 'logistic' curve of population growth is being given additional social applications."[18]

There are even social sciences called ethno-history and social physics. To some the study of language seems to be a science. Two anthropologists have declared that "the methods of linguistics are . . . the most distinctive as well as the best defined in the social sciences."[19]

Regardless of one's definition of the social sciences there are obvious differences in approach and method compared with those of the natural sciences. In the social sciences, experimentation must take a different form. Prediction and control are frequently lacking. Much time, sometimes decades, is required before universal generalizations can be made, if at all. The study of social institutions involves values, emotions, and opinions to a much greater extent than the pursuit of mathematics or astronomy. There is greater complexity; ideological matters impinge upon researcher and subject to a greater degree.

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[16] Gray in Thornton, *Science and Social Change*, p. 479.

[17] For a more detailed description of these disciplines see United States Department of Labor, Bureau of Labor Statistics, *Employment Outlook in the Social Sciences*, Bulletin no. 1167, and *Personnel Resources in the Social Sciences and Humanities*, Bulletin no. 1169.

[18] Stewart, "A Basis for Social Physics," *Impact of Science on Society*, vol. III, no. 2 (summer, 1952), p. 113.

[19] Kroeber, Alfred L. and Kluckhohn, Clyde, *et al.*, *Culture: A Critical Review of Concepts and Definitions* (Cambridge, Mass.: The Museum, 1952), p. 124.

Indeed, attempts by the social scientists to pattern their methods after those in the pure sciences are likely to prove futile. There are sufficient differences to justify different approaches. At the same time, there is evidence that the social sciences are of increasing importance in our time and the supply and quality of scientists in this area should be of concern. Some years ago a Congressional committee came to the following conclusion:

> "We are firmly convinced that the program of support of the basic sciences should include those fields of inquiry known as the social sciences. While it is true that these younger disciplines have not had time to perfect their specialized techniques, they have already developed to a degree which enables them to make significant contributions to almost every department of government. With a carefully planned and administered program of support, the social sciences promise to make even more important contributions to the solution of the problems of the future."[20]

The strategic role of the social sciences is all the more important when we discover that this area has been slighted in the past. Although there do not appear to be the same critical shortages of personnel at present in the social science fields that there are in the physical sciences, the heavy emphasis on the natural sciences by the federal government and the public has resulted in a general neglect of this field. Research contracts, fellowships, and other tangible evidences of interest and encouragement in social science fields are slight when compared with those in the more exact sciences.

What has the federal government done in this respect? Richard Axt has pointed out a long-term trend in favor of the natural sciences at the expense of the social sciences and humanities.[21] This trend, however, goes back to the mid-nineteenth century and can hardly be blamed exclusively on the atomic bomb. There is evidence that recently there has been more interest in the social science area by those in government. Federal support of social science research projects now does not exceed two million dollars a year. Only about 10 per cent of this kind of university research, therefore, is being financed by the federal government while there are estimates that over 90 per cent of natural science research in university laboratories has such support.[22] Almost a decade ago, Senator Kilgore declared on the floor of the Senate, "The social sciences involve many problems which have to be solved by the natural sciences (and vice versa) . . . . it is impossible to draw a distinguishing line between the social sciences and the natural sciences."[23]

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[20] United States Congress, Senate; 79th Congress, 2nd Session, *Report on Science Legislation from the Subcommittee on War Mobilization to the Committee on Military Affairs, Report No. 8*, p. 6. For additional examination of the social sciences see Northrop, *op. cit.*, p. 255ff; Riesman, *Individualism Reconsidered*, p. 467ff; Whiteway, *Scientific Method and the Conditions of Social Intelligence*, p. 47.

[21] Axt, *The Federal Government and Financing Higher Education*, p. 114.

In 1948 a poll of some 4,000 scientists indicated that about 80 per cent of them believed that the social sciences should be included in any federal research support. As these sciences of man improve and refine their techniques, and as it becomes more evident that there is greater demand for the services of the social sciences, more concern will have to be given to their welfare.

It is possible that that day may not be too far distant. Experts are beginning to point out our deficiencies in this area, the need for improved quality in the education of our social scientists, and the need for careful attention to recruitment in this field. Nokes has declared that the great need in our time is for an improvement in human relations, and it was E. C. Stakman who asserted:

> "Science is needed in solving problems of human subsistence: when two-thirds of the world is poorly fed and part of the remainder is overfed, we need to put science and ethics to work. When we profess the brotherhood of man and cannot act the part and do not know why, we should at least make the attempt to put science to work in studying human relations."[24]

Despite their differences in method, results, and precision, there are fertile areas for progress in the social sciences which we should encourage with care and patience. Social scientists may never see the day when economic analysis has dispelled the uncertainties of business cycles, when political economy has replaced the vagaries of the electoral hustings, when anthropology, social psychology, and history have removed the prejudices and misunderstandings of men, but in our concern over the more exact sciences we should not overlook the infants in the family. Because this aspect of the study of science is unique, a brief consideration of the role of political science in the United States written by Herbert A. Deane is appended to this study.

Having briefly examined the sciences, let us now consider what is meant by the term scientist. Among the more rewarding of the many studies of scientists that have been made since 1900 are those by Cattell, Visher, Knapp and Goodrich, and Anne Roe.[25] Here again there is no single acceptable definition. Scientists are people who have received advanced specialized education and who perform activities that involve some aspects of the scientific methods. Perhaps the best way to define scientists is to describe their characteristics in terms of activity, personality, and outlook. They work at a variety of tasks which involve careful inquiry and detailed examination of physical phenomena and place heavy demands on rational faculties. They make use of experimentation and verification and must employ extensively their inductive reasoning, structural visualization, judgment, and quantitative and verbal ability.

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[22] Steelman, *Science and Public Policy*, vol. 1, p. 107. See also Hubbert and Rosenberry, *Opportunities for Federally Sponsored Social Science Research; Allen, The Federal Government and Education*, pp. 281–282.

[23] Kilgore in *Congressional Record*, July 1, 1946, p. 8157.

[24] Stakman, "Science and Human Affairs," *Science*, vol. 113 (Feb. 9, 1951), p. 140.

As a group they have remarkable intelligence. The median IQ of the eminent scientists studied by Anne Roe was 166.[26] C. Gilbert Wrenn has reported a median IQ of 141 for Ph.D. recipients. Of course, it is not necessary to have this high a level of ability in order to do satisfactory work as a scientist. However, as A. W. Haslett has observed, the most significant characteristic of a scientist is high intelligence. High mathematical ability, and in some fields relatively high verbal ability, are also found. Apparently, physical scientists are also capable of a complex order of imageless thinking which is not as frequently found in other fields.[27]

According to recent reports, scientists tend to be characterized by considerable occupational and geographical mobility. In a 1948 study of a 5 per cent sample of persons with the Ph.D. in science, it was discovered that although a majority spent the greater part of their working lives in one specialty or in closely related fields, a significant minority transferred from one branch of a science to another and even to another scientific discipline. Furthermore, more than 60 per cent obtained their bachelor's and doctor's degrees in different states.[28]

Sheer intelligence does not in itself suffice to make a scientist; in temperament, the attributes of a strong curiosity, a persistent industriousness, imagination, patience, and a love for prolonged periods of intellectual endeavor are also essential. A person who looks on research as exciting and who finds originality and the joy of new knowledge worth long hours of discomfort and fatigue usually has the prerequisites for scientific success.[29] Paul Brandwein's term "questing" aptly describes this combination of drive, dissatisfaction with inconsistencies and gaps in existing knowledge, and devotion to discovery.[30]

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[25] Cattell and Brimhall (eds.), *American Men of Science;* Visher, *Geography of American Notables*, and *Scientists Starred, 1903–1943;* Knapp and Goodrich, *Origins of American Scientists;* Roe, *The Making of a Scientist.*

[26] Roe, *op. cit.*, p. 144, 164.

[27] Haslett, *Science in Transition*, p. 11.

[28] United States Department of Labor, Bureau of Labor Statistics, *Occupational Mobility of Scientists*, Bulletin no. 1121 (1953), p. 4, 30.

[29] See Roe, *The Making of a Scientist*, p. 58; Wolfle, "Intellectual Resources," *Scientific American*, vol. 185 (Sept., 1951), p. 42.

Introversion has been frequently cited as a characteristic of the scientist, and he is indeed perhaps the best example of Riesman's "inner-directed" personality. Either because of his make-up or as a result of his work, the scientist tends to be reflective and self-reliant. However, since modern research requires increasingly extensive teamwork among scientists, the ability to work compatibly with other researchers is becoming more important. Frequently, too, because of his intense drive and high demands, the scientist is likely to be depressed by the very accomplishments toward which he has worked so hard. Anne Roe has described the deep depression after high achievement which frequently plagues the eminent scientist.[31]

Willingness to challenge opinions is another important trait of most scientists. Don Price has pointed out that this characteristic leads scientists to think about public issues in somewhat different terms than the average citizen. Since the scientist views himself as devoted to the search for truth, Price believes that he tends to look for the "support and protection of [scientific] institutions independent of the fluctuations and pressures of business competition or of politics."[32] The average citizen frequently does not understand this attitude. In all matters, the scientific personality is one that is not persuaded by authority nor deterred by dogma. Indeed, Terman has suggested that in abilities, interest, and social behavior, scientists are at the opposite end of the pole represented by businessmen and lawyers. The scientific personality must question and must never be completely satisfied by the answers. H. A. Spoehr has characterized the scientist in these terms:

> "There is an old quip which defines a scientist as a man who is of a different opinion. While this impression has undoubtedly been much abused, it is true that scientists do not stand in awe of authority nor do they regard the established order within their domain as absolutely inviolable. If there were no differences of opinion there would be little progress. Scientists are essentially pioneers and progressives, and progress rarely goes hand in hand with conformity. New ideas and fresh relationships of more established ideas are the main concerns of science."[33]

Generalizations about the scientific personality are hazardous. But in examining those of rare ability who have made outstanding achievements in the scientific as well as the nonscientific fields, one is struck by their great versatility, their wide interests. Whether it is Leonardo de Vinci or Einstein, the really great scientist has been a man of exceptionally broad interests and humanistic and philosophical leanings that supplemented his more technical accomplishments.

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[30] Brandwein, *The Gifted Student as Future Scientist*, p. 10. See also Subarsky, "What is Science Talent?" *The Scientific Monthly*, vol. LVI, no. 5 (May, 1948), p. 377.

[31] See Riesman, *The Lonely Crowd*, p. 15; Brandwein, *op. cit.*, p. 56; Roe, *op. cit.*, p. 238.

[32] Price, *Government and Science*, p. 198; see also Terman, "Are Scientists Different?" *Scientific American*, vol. 192, no. 1 (Jan., 1955), pp. 25-29.

[33] Spoehr, "Society in the Grip of Science," *Impact of Science on Society*, vol. IV, no. 1 (spring, 1953), p. 9.

Scientists themselves have indicated what qualities they consider most significant. They include "perseverence, curiosity, mental alertness, initiative, and critical insight." Other personality traits highly valued are "enthusiasm, energy, and exceptional honesty." One scientist has listed the following essentials to success in his field: "ability, interest, ambition to achieve; benefiting as a student by the encouragement of one or more able professors." Another has declared, "My success was largely due to my enthusiasm, patience, persistence, and ability to work steadily for long hours."[34]

Perhaps it is in their attitude that scientists are best characterized. Almost a decade ago a survey was undertaken of the attitudes of a cross-section of American scientists and the results were published as an appendix to volume III of the Steelman Report.[35] Intellectual satisfactions were given primary emphasis by the scientists in evaluating working conditions. Universities were selected most frequently as the best places to work because of the relative freedom from restriction. Similarly, in a study of the reasons why scientists left government employment, it was discovered that restrictive supervision and administrative control ranked high.[36]

This is mentioned to underscore what Knapp and Goodrich have called the "philosophical orientation" of the scientist. In his attitudes toward work and life in general the scientist has a scale of values that are centered around high-level intellectual endeavor and that involve an unshakable faith in cause and effect relationships. "To be a physicist," Julian S. Schwinger has declared, "is to believe that everything has a relationship to every other thing."[37] The outlook of the scientist is one that states in effect that in the study of the physical universe the knowledge and values of life are to be found. Interest in the objective world, the fundamental laws of the universe, the unknown and the unexplained—it is from these that the scientist takes his bearings.

The scientific attitude cannot be completely understood if it is dealt with solely in rational terms; scientists display an almost irrational attachment to their work. They are driven to it; their attention and energy are completely absorbed in their labors. The physicist DuBridge has pictured this pronounced enthusiasm in these words, "Being attracted to physics is very much like falling in love. It is an almost unexplainable and an almost emotional experience."[38] For many it is a calling, just as much so as for ministers or missionaries. The gospel may be the periodic table, the quantum theory, cytology, or complex numbers, but the devotion befits a Benedictine monk. Kepler's joy at discovering his laws of planetary motion well expressed this aspect of the scientific attitude:

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[34] Visher, *Scientists Starred*, p. 105, 549.

[35] Steelman, *Science and Public Policy*, vol. III, pp. 205–6.

[36] American Association for the Advancement of Science, *Second Conference on Scientific Manpower*, p. 10.

[37] Quoted in White, "U. S. Science: The Troubled Quest," *The Reporter*, vol. XI, Sept. 14, 1954, p. 14.

> "It is not 18 months since I got the first glimpse of light, three months since the dawn, very few days since the unveiled sun, most admirable to gaze upon, burst upon me. Nothing holds me; I will indulge my sacred fury: I will triumph over mankind by the honest confession that I have stolen the golden vases of the Egyptians to build up a tabernacle for my God far away from the confines of Egypt . . . . the die is cast, the book is written, to be read either now or by posterity, I care not which; it may well wait a century for a reader, as God has waited six thousand years for an observer!"[39]

It is not only in the days of rebellion against the pre-Copernican system that such an attitude characterized the scientific mind. Poincaré spoke for all those of scientific outlook when he declared, "Intellectual beauty is sufficient unto itself, and only for it . . . does the scholar condemn himself to arduous and painful labors."[40]

So far, we have been speaking about the personality and outlook of the scientist. What about the engineer? Many of the same traits are in evidence. A study at Cooper Union has produced a picture of the desirable engineering graduate. He displays a spirit of inquiry. He has the ability to "set standards of accomplishment . . . . devise solutions to problems . . . . manipulate engineering materials and devices . . . . convey ideas . . . ."; he also has "a knowledge of scientific, engineering, and humanistic principles and concepts . . . . a desirable personal philosophy."[41]

In the popular stereotype, the engineer is perhaps a more practical person than the scientist. His interest in the application of scientific knowledge to technical fields in commerce and industry and his preoccupation with applied rather than basic research probably set him somewhat apart from the scientist. He realizes his importance in a technical world and frequently sees his accomplishments valued more highly by the general public than the little known but eventually far more significant achievements of the research scientist.[42]

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[38] Quoted in National Manpower Council, *A Policy for Scientific and Professional Manpower*, p. 185. See also "The Scientists," *Fortune*, vol. XXXVIII, no. 4 (Oct., 1948), p. 110.

[39] Quoted in Nagel, "The Development of Modern Science," *Chapters in Western Civilization*, vol. 1, 1st ed., p. 261.

[40] Quoted in Ramon y Cajal, *Precepts and Counsels on Scientific Investigation*, p. 62.

[41] American Society for Engineering Education, *Proceedings of the Society for the Promotion of Engineering Education*, vol. LII (1944), p. 37.

What generalizations can we draw about the origins of scientists and engineers? In the growing literature on this subject, perhaps the best known works are Knapp and Goodrich's *Origins of American Scientists* and Knapp and Greenbaum, *The Younger American Scholar, His Collegiate Origins*. Also informative is the 1951 Bureau of Labor Statistics study of *Employment, Education, and Earnings of American Men of Science*. Visher's volumes on *Scientists Starred, 1903–1943*, and *Geography of American Notables* provide useful information about the geographical origins of some eminent scientists. A useful 1954 study of the undergraduate origins of outstanding engineers is Warren E. Wilson's *A Measurement of Success of Engineering College Graduates*, still in mimeograph form. Anne Roe's *The Making of a Scientist* suggests a number of hypotheses about the origins of scientists in the United States.

These studies indicate that scientists tend to emerge from families of moderate means in which a high value has been placed on learning and on the intellectual aspects of life. Frequently, they tend to be the first-born in the family; 60 per cent of the eminent scientists studied by Anne Roe were in this category, many more than would be expected by sheer chance.[43] This would seem to suggest that the considerable personal independence which the first-born is obliged to develop may contribute to the shaping of a scientist. Francis Galton, whose monumental study of genius is one of the outstanding works in the field, also found that having a well-balanced and unusually intelligent mother showed a high correlation with success in science.[44]

As might be expected, the findings of particular studies of the economic origins of scientists vary somewhat. Cattell and Brimhall indicated that almost half of the fathers of the scientific men included in their volume belonged to the professional class.[45] Bowerman has reported similar evidence suggesting that the professional ranks contribute heavily to produce scientists; the middle and upper classes seemed to predominate in the men whom he studied.[46] In the more recent studies which Knapp and Goodrich have made the preponderant majority of scientists appears to have come from middle and lower middle-class families; these authors conclude that scientists appear to come from those groups which have considerable social mobility but relatively limited vocational opportunities.[47] However, most of the eminent scientists studied by Anne Roe came from upper middle-class homes.[48]

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[42] For an eloquent description of the engineer, see Bush, *Endless Horizons*, p. 141.

[43] See Roe, *op. cit.*, pp. 71–74.

[44] Galton, *Hereditary Genius*, p. 189.

[45] Cattell and Brimhall, (eds.), *American Men of Science*, p. 784.

[46] Bowerman, *Studies in Genius*, pp. 52–53.

[47] Knapp and Goodrich, *Origins of American Scientists*, p. 6, 279, 282, 292.

[48] Roe, *op. cit.*, p. 69, 90.

TABLE 1

SCIENTISTS' *birthplaces by states*[a]

Rank	*State*	*Index number*[b]	*Rank*	*State*	*Index number*[b]
1.	Colorado	68	39.	West Virginia	14
2.	Utah	61	40.	Texas	13
3.	Massachusetts	57	41.	Louisiana	13
4.	Connecticut	56	42.	Florida	12
5.	New Hampshire	55	43.	Kentucky	12
6.	Montana	54	44.	New Mexico	11
7.	Wyoming	53	45.	Alabama	11
8.	Vermont	51	46.	Tennessee	10
9.	California	49	47.	Georgia	10
10.	Washington	48	48.	Arkansas	9

[a] Source: Huntington, *Mainsprings of Civilization*, p. 82. Only the 10 highest and the 10 lowest ranking states in productivity of scientists are given here.

[b] Births of scientists per 100,000 children under one year of age at the census nearest the date of birth.

In addition, according to Knapp and Goodrich, the small centers of population and the semi-rural areas of the country appear to have been fertile breeding grounds for scientists. Although there is less evidence on this point, it would also appear that the public school tended to produce proportionately more scientists than the private school.[49]

Geographically, there is a wide range in the productivity of an area insofar as turning out scientists is concerned. In his study of the birthplaces of scientists starred in the *American Men of Science* series, Visher found a yield of 222 per million for Massachusetts, 158 per million for Connecticut, and 120 per million for Minnesota. At the other end of the scale, Arkansas is credited with a rate of two starred scientists per million, Oklahoma with three, and Mississippi with four. New England ranks first among the geographical regions in this study; the South ranks lowest.[50]

It can be argued, however, that such birthplace indices, while informative, do not present a fair gauge of a state's ability to produce scientists because the index is based on the number of births in proportion to the entire population. In some states the number of births proportionate to the population is higher than in others. It might also be argued that scientists starred in an edition of *American Men of Science* do not necessarily represent a cross-section of the scientific population.

In order to meet these two objections, other indices can be computed on the basis of the total number of scientists born in each state and the number of children born in each state in the same year. Table 1 gives the results of such a computation for the top ten and the lowest ten states indicated by this method. Again, it is obvious that the South has the lowest productivity of any region. Top honors appear to be shared equally by Western and New England states. Ellsworth Huntington, who has worked out this method and the table in studying the birthplaces of leaders in all fields, has identified a band extending roughly from Connecticut through California that takes in the areas having the highest productivity of ability. It also may be significant that Utah, ranking first among states in college-going in 1950, stands second insofar as the natal origins of scientists are concerned. Colorado, with the highest index for scientists' birthplace, stood third in terms of 1950 college-going.

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[49] Knapp and Goodrich, *op. cit.*, p. 278; Roe, *op. cit.*, p. 77.

[50] Visher, *Scientists Starred, 1903–1943*, pp. 398–399.

More recently Anne Roe's study of 63 eminent scientists revealed that 25 of them came from the Midwest, 20 from the East, 14 from the Far West, and only 4 from the South. Obviously, these figures were too small to permit generalizations.[51]

When we examine the education of scientists, it is clear that the leading region for their education has been the Middle West. In a study which the Bureau of Labor Statistics made in 1951, it was reported that about one-third of the bachelor's degrees in science and 40 per cent of the science doctorates were awarded in this region. If we consider educational productivity in terms of population, New England gave 56 bachelor's degrees to scientists per 100,000 population; the North Central States, 38; the Mountain States, 37; the Pacific area, 35; the Middle Atlantic, 27; and the South, 12. This study also uncovered significant differences between states within regions:

> "Within each region, there were distinct differences among areas in the proportion of degrees awarded the various specialists. Thus, all the earth scientists who studied in New England received their doctorates in either Massachusetts, Rhode Island, or Connecticut. Virginia, West Virginia, Kentucky, North Carolina, and Tennessee produced most of the South's mathematicians. Thirty-two per cent of all the agriculturists with Ph.D.'s came from schools in Iowa, New York, New Jersey, or Pennsylvania. California educated most of the specialists in physics and electronics who received their doctorates on the West Coast."[52]

Individual undergraduate origins of scientists have been most extensively reported on by Knapp and Goodrich in their volume, *Origins of American Scientists.* Taking the third and seventh editions of *American Men of Science,* they made an examination of the undergraduate origins of those scientists with doctorate degrees in an effort to see which were the most productive institutions. The results of their survey revealed that those colleges of modest cost in the Middle and Far West which attract students in large proportion from semi-rural regions appeared to be most productive. In addition, it appeared that the liberal arts college with a strong intellectual orientation was the most productive type of higher educational institution in turning out scientists. A subsequent study by Knapp and Greenbaum, *The Younger American Scholar,* presents later and somewhat different findings. Examining the productivity of institutions since World War II in graduating a particular type of scholar, the study concluded that institutions of high cost are currently unusually productive, that the difference between geographical regions is not as pronounced as had been found in the earlier study, and that the difference in productivity between liberal arts colleges and universities was similarly less pronounced. At the same time, it appeared that the most costly institutions were more distinguished in producing scholars in the non-science fields than in science.[53]

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[51] See Roe, *op. cit.,* p. 66.

[52] United States Department of Labor, Bureau of Labor Statistics, *Employment, Education, and Earnings of American Men of Science,* p. 15.

The Wesleyan studies contain many provocative implications for the problem of encouraging scientific talent. For example, the studies show that a relatively small number of institutions are directing a large proportion of their graduates into scientific and other scholarly careers. The institutions that emphasize what Knapp and Goodrich call "the intellectual enterprise for its own sake" seem to be most productive of scientists. Catholic institutions appear to have a disappointingly low productivity rate while liberal Protestant schools, Knapp and Goodrich contend, have exerted a strong influence in favor of scientific endeavor. It seems apparent from these findings that recruitment of more scientists might be accomplished by looking to the many institutions where now virtually none are produced.[54]

The role of Protestantism in encouraging the production of scientists comes in for special attention in the Knapp and Goodrich study. In their opinion, the number of scientists coming from American Protestant groups has been disproportionately large. Examining the various reasons for the close relationship between Protestantism and scientific productivity, the authors conclude that the association is stronger than a fortuitous connection. They suggest that elements in Protestantism have strengthened scientific activity either because Protestantism has allowed a certain secularization of thought or because basically its doctrines are more friendly toward science and the scientific methods than Catholicism. For instance, the authors point out the compatibility between Calvinist beliefs in predestination and modern scientific determinism. Citing the work of Kingsley Davis, the authors see in the Protestant ethic the emphasis on asceticism, sobriety, individualism, self-reliance, material values, and rational empiricism which are prerequisites to the development of a scientific attitude.[55]

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[53] Knapp and Greenbaum, *The Younger American Scholar,* p. 39, 94.

[54] Knapp and Goodrich, *op. cit.,* p. 274, 287; see also Knapp and Greenbaum, *op. cit.,* pp. 93-4.

It is interesting to note that data presented by Visher, Lehman, and Roe tend to corroborate this interpretation. Of the 65 eminent scientists whom Anne Roe studied, one came from a Catholic home, five were from Jewish homes, and 59 had Protestant backgrounds.[56] However, one must be careful in using such statistics for the past when making interpretations about the present or future production of scientists. Because of the bases of selection and the many variables involved in such studies, conclusions drawn from such data are bound to be limited and highly tentative.

More study has been devoted in the past to the undergraduate origins of scientists than to those of engineers. Recently, however, Warren E. Wilson attempted to measure the success attained by graduates of different engineering colleges. Confining the study to those who completed work for a bachelor's degree in engineering during the period from 1926 to 1930, Wilson used inclusion in the 1948 edition of *Who's Who in Engineering* as his measure of success. He then derived a productivity index for each of the colleges now accredited by the Engineers' Council for Professional Development by dividing the total number of graduates in the five-year period studied by the number of *Who's Who* engineers. The data reveal that the Great Plains and the West Coast areas produced successful engineering graduates at a significantly higher rate, that the schools in the first quarter generally are smaller in enrollment than those in the second and third quarters, but that very large colleges have unusually high productivity indices. Wilson's report also reveals that over the last 30 years about one-quarter of those in his study received master's degrees in addition to their bachelor of engineering degrees.[57] Table 2 lists the most productive colleges according to Wilson's computations. As in the case of similar studies, it must be borne in mind that statistics on productivity can be misleading, particularly when taken out of context. In the case of Wilson's study, for instance, the figures apply only to graduates in engineering during

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[55] Knapp and Goodrich, *op. cit.*, p. 274, 276.

[56] Roe, *op. cit.*, p. 61.

[57] Wilson, *A Measurement of Success of Engineering College Graduates* (mimeo). For an earlier study which lists only the total number of graduates from each college listed in *Who's Who in Engineering* see Prentice, "College Alumni Listed in Who's Who in Engineering," *Mechanical Engineering*, vol. LXXI (Jan.–June, 1949), p. 397.

TABLE 2

DISTINGUISHED ENGINEERS: *productivity of individual colleges (top quarter)*[a]

		Graduates 1926–1930	*Graduates listed in Who's Who in Engineering*[b]	*Index of productivity*[c]
[d]1.	Municipal University of Wichita	4	1	250.0
[d]2.	Wayne University	9	2	222.2
3.	California Institute of Technology	286	37	129.2
4.	Columbia University	147	16	108.9
5.	Rutgers University	145	13	89.6
6.	Princeton University	127	11	86.6
7.	Harvard University	185	16	86.5
[d]8.	University of South Carolina	24	2	83.3
9.	University of Louisville	42	3	71.5
[d]10.	Utah State Agricultural College	28	2	71.4
11.	Johns Hopkins University	279	19	68.0
12.	University of Iowa	282	19	67.4
13.	Stanford University	355	23	64.8
14.	Vanderbilt University	64	4	62.5
15.	University of Rochester	32	2	62.5
16.	Northwestern University	96	6	62.5
17.	University of Colorado	390	24	61.6
18.	Missouri School of Mines	292	18	61.6
19.	University of Washington	417	25	60.0
20.	City College of New York	100	6	60.0
21.	University of Kansas	387	23	59.5
[d]22.	Southern Methodist University	17	1	58.8
23.	University of Minnestoa	791	46	58.1
24.	University of Nebraska	338	19	56.2
25.	University of Virginia	110	6	54.5
26.	University of Arkansas	96	5	52.1
27.	University of North Dakota	136	7	51.5
28.	Tufts College	273	14	51.3
29.	Drexel Institute of Technology	215	11	51.2
30.	University of Pennsylvania	294	15	51.0
31.	South Dakota State College of Agriculture and Mechanic Arts	129	6	46.4
32.	New York University	431	19	44.0
33.	University of Michigan	1,366	59	43.2
34.	University of Wisconsin	744	32	43.1

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[a] Source: Wilson, *A Measurement of Success of Engineering College Graduates.* Only the colleges ranking in the top quarter of the full table are given here.

[b] 1948 edition.

[c] Number of graduates in *Who's Who in Engineering* per thousand graduates.

[d] Since these colleges had less than 30 graduates in the period studied, their ratings are probably not statistically valid.

the years from 1926 to 1930. The Massachusetts Institute of Technology, with a long tradition of excellence in the preparation of engineers, is not among the top quarter of engineering colleges in Wilson's study despite the fact that it produced 83 graduates in this period who are listed in the 1948 edition of

Who's Who in Engineering. With 2,218 graduates during these years, M.I.T.'s productivity index is 37.4.

Apart from undergraduate origins of scientists and engineers, it is apparent that scientists and engineers frequently show marked interest in their future fields of work and even decide to enter them quite early in their lives. The scientists among the gifted in Terman's group revealed an early predilection toward science.[58] Visher's study found that almost a quarter of the scientists had decided to enter science before the age of 15 and that half of them had made up their minds to become scientists before the age of 18. Among chemists, 60 per cent had chosen their careers before the age of 18.[59] The Knapp and Goodrich data indicate that the proportion of those making similar decisions early is increasing. Among the scientists educated prior to 1918 in their study, 28 per cent reported having chosen a scientific vocation before the age of 17. For those who went to college in the early 1920's, 36 per cent determined upon a science career by 17. During the years 1924 through 1934, 41 per cent were committed to a career in science before reaching 17, and since 1934, 55 per cent had so decided by that age. Whereas 30 per cent prior to 1918 did not decide on a scientific career until after their twentieth year, only 5 per cent in more recent times waited that long to make such a decision.[60]

Other studies agree on this point. In 1902, a Swiss periodical surveyed a number of mathematicians and discovered that 35 per cent were drawn to the subject before the age of 10, and 43 per cent showed keen interest in mathematics between the ages of 11 and 15.[61] The eminent scientists in Anne Roe's study were characterized by an early commitment to science.[62] A 1948 study of a 5 per cent sample of Ph.D.'s in science reported that for four out of five of them an interest in a particular branch of science was already well developed by their junior year in college. A 1954 report stated that about 60 per cent of a sample of outstanding scientists had made the decision to pursue a scientific or engineering career while in high school.[63] Some educators now believe that between 60 and 70 per cent of those now getting advanced degrees in science made their vocational choices before entering college. If this is the case, it has an important bearing on the question of recruiting for science.

In addition to an early commitment, the importance of exposure to scientific study seems to characterize the early years of most scientists. Anne Roe makes much of the point that a research experience—a realization that one can perform and enjoy a scientific experiment—acts as a great stimulus to interest in science.[64] This is a conclusion shared by Visher[65] and others; indeed, almost anyone who studies the lives of scientists will notice that the encouragement of their natural ability through laboratory or employment opportunities generally played a significant role in drawing them toward scientific careers.

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[58] Terman, "Are Scientists Different?" *Scientific American*, vol. 192, no. 1 (Jan., 1955), p. 25.

[59] Visher, *op. cit.*, p. 90, 546.

[60] Knapp and Goodrich, *op. cit.*, p. 239, 419.

[61] Bell, *Men of Mathematics*, p. 547.

[62] Roe, *op. cit.*, p. 70.

[63] United States Department of Labor, Bureau of Labor Statistics, *Occupational Mobility of Scientists*, Bulletin no. 1121, p. 3. A similar picture of early commitment was revealed in a study of 600 winners and honorable mention winners of recent science talent search competitions. See MacCurdy. *Characteristics of Superior Science Students*.

But perhaps the most important source of encouragement to future scientists is the teacher. More than anyone else, the teacher is in a position to stimulate a youngster with scientific talent and to direct his thinking towards a scientific or engineering career. Scientists have consistently pointed out the crucial role which their own teachers played in helping to shape their career decisions. Among the scientists studied by Visher, more than 40 per cent identified college teachers as the chief source of personal influence; high school teachers were similarly singled out by another 16 per cent.[66] In the Knapp and Goodrich study, scientists were again asked to give the factor that had been most important in their career decisions. In the group educated prior to 1918, 36 per cent cited the example or encouragement of a college teacher. For the period 1918 to 1924, the percentage was 34; for the following decade it was 31. Of those educated since 1934, only 18 per cent indicated that a college teacher had been the prime stimulator to a science career. Thirteen per cent of the early group listed a high school teacher as the most important factor in their making a decision. For the group educated since 1934 the example or encouragement of a secondary school teacher was cited as most important by 19 per cent.[67]

The importance of individual encouragement in the shaping of future scientists cannot be overemphasized. The teacher, whether in elementary school, high school, or college, who can ignite that spark of interest in the talented, who can make his subject live in the minds of his pupils, and who, despite the routine drudgery of an underpaid, harassed profession, can stimulate, fascinate and inspire; he, in the final analysis, is the one who can most effectively encourage scientific talent. Indeed, it is the prevailing opinion among educators today that the current shortage of scientists and engineers is principally the result of a decrease in the quantity and quality of the nation's high school science teachers.

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[64] Roe, *op. cit.*, p. 81.

[65] Visher, *op. cit.*, p. 111.

[66] Visher, *op. cit.*, p. 91.

[67] Knapp and Goodrich, *op. cit.*, p. 419. See also Cattell and Brimhall, *American Men of Science*, pp. 788–789.

Scientific ability and its identifiation

It is obvious from common knowledge, and clearly evidenced in the summation of literature on the characteristics of scientists presented in the introduction, that high intelligence is one of the most important requisites for a scientific career. In considering how the development of scientific talent in the United States might be encouraged, it is therefore pertinent at the outset to remark on the incidence of high intellectual ability in the American population and to review what is known about this ability. It has been estimated that about 2 per cent of those now between five and 19 years old can be considered mentally gifted. Others have defined the gifted as the top 1 per cent of the school population. Lewis Terman, using the Stanford-Binet intelligence test ratings, has estimated that about 3 per cent of the population have IQ's of 125 or more and about 1 per cent possess IQ's of 130 or more.[1] C. Gilbert Wrenn has produced another estimate, placing the proportion of 18-year-olds in 1950 having an IQ of 125 or higher at 6 per cent, and the proportion with an IQ of 140 or higher at 0.6 per cent.[2] An IQ of at least 125 is considered necessary for satisfactory graduate study. By this criterion, approximately 132,000 persons in each one-year age group in the college-age population have the ability to earn the Ph.D. The number of Ph.D. degrees conferred in 1953–54 was 8,996.[3]

Discussions of high intellectual ability usually draw distinctions between certain generally accepted levels of intelligence. At the top is the person of genius who usually posseses both a high degree and an unusual quality of talent as well as the ability to display his intellectual powers in original and creative ways.[4] Furthermore, according to Galton, the genius possesses a new variety of ability not quite definable in terms of normal human intelligence.[5] There are no more than a handful in this category in any age group.

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[1] Terman, *The Measurement of Intelligence*, p. 78.

[2] Wrenn, "High Level Research Talent," in National Research Council, *Human Resources and the Fields of Higher Learning*, p. 25.

[3] Garrison, *The Psychology of Exceptional Children*, p. 9; Witty and Bloom, "Education of the Gifted," *School and Society*, vol. LXXVIII Oct. 17, 1953, p. 114; United States Department of Health, Education, and Welfare, Office of Education, *Earned Degrees Conferred by Higher Educational Institutions, 1953–1954*, Circular 418, p. 1, Washington, 1955.

[4] Baldwin, James Mark, *Dictionary of Philosophy and Psychology*, vol. 1 (New York: The Macmillan Co., 1901), p. 450.

The gifted or "highly gifted" person is considered to be someone in the top 1 to 10 per cent in general intelligence whose ability is so great or so unusual compared with the average person that his talents sit like a gift upon his shoulders. Giftedness is also sometimes identified with special, highly developed abilities not necessarily connected with high intelligence. More frequently, however, it is convenient to associate it with general intelligence, which has been described as the "power to achieve literacy and to deal with its abstract knowledge and symbols." Leta Hollingworth's studies of gifted schoolchildren have enhanced our understanding of this segment of the population.[6]

A third level of intelligence is known by the term superior. At this level the contrast with what is called the average is less distinct. David Wechsler has put it this way: "The superior person is one who can do very much more of, or very much more quickly, or very much better, the kind of thing which the average person can do only in a moderate degree."[7]

Contrary to the popular view, those with high intelligence tend to be stronger, taller, and healthier than those whose mental faculties are only average. The stereotype of the intellectual giant, all brain with puny, wizened frame, is contrary to fact. Although their physical characteristics are less distinguished than their mental ones, intellectually gifted persons generally also get superior ratings for their nonintellectual qualities. Furthermore, contrary to popular opinion, this group is apparently less likely to experience nervous breakdowns or to have difficulty making emotional adjustments. Recently, Paul Witty has criticized the popular belief that bright children are "eccentric and emotionally unstable," to be shunned or regarded with suspicion. He has declared that even today "an unfortunate or unfavorable attitude toward the gifted persists to some extent, even though the spread of knowledge concerning them is gradually changing the stereotyped concept."[8] Of course, because of his greater knowledge and sensitivity, the intelligent person is more likely to be aware of complexities and problems which an individual of average intelligence overlooks, Herbert A. Carroll has suggested. In addition, Terman, Garrison, and others have pointed out that gifted children also seem to possess strong moral traits.[9]

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[5] Galton, *Hereditary Genius*. See also Wechsler, *The Range of Human Capacities*, p. 124ff; Bowerman, *Studies in Genius*, p. 7.

[6] See Hollingworth, *Children Above 180 I.Q.*; Hollingworth, "How Should Gifted Children Be Educated?" *Baltimore Bulletin of Education*, vol. 2 (May, 1931), p. 195; Educational Policies Commission, *Education of the Gifted*, p. 43; Witty, *The Gifted Child*.

[7] Wechsler, *The Range of Human Capacities*, p. 129.

[8] *The New York Times*, November 28, 1954.

[9] Garrison, *The Psychology of Exceptional Children*, pp. 203–218; Olson in Henry (ed.), *Adolescence*, 43rd Yearbook of the National Society for the Study of Education, p. 62.

Although history records many more gifted men in the past than gifted women, it is difficult to draw sweeping conclusions about the intellectual superiority of one sex over the other. This is a subject that is currently being explored on a number of fronts. Some studies in the past have suggested that there were sex differences in intelligence. Terman, for instance, found a ratio of 115 boys to 100 girls among the gifted children he studied. In college aptitude tests boys have excelled in mathematical ability and the ability to understand spatial relationships while girls have excelled in verbal and memorizing abilities. In a memorandum prepared for this study, Jane Blizard has suggested that the sex differences which exist in test scores are probably the result of socio-cultural influences. The Commission on the Education of Women of the American Council on Education has concluded that what differences there may be between the abilities of men and women are less important than differences in motivational patterns.[10]

In addition to the concept of intelligence, it is important to note the distinction frequently made between general ability and specific abilities. This is a complex subject, a realm where different psychological theories contend with each other, where the relative importance of heredity or environment is hotly disputed, and where the limitations of human measurement still handicap us. What we call mental ability appears to be made up of specialized abilities, the most important of which are verbal, numerical, and spatial abilities. However, the answer to whether there is one major general ability factor along with a number of less important, special abilities, or whether there are just an unknown number of special abilities comprising human talent or intelligence, must await further research.[11]

Of the special abilities which are considered to be important in contributing to high intelligence, verbal ability appears to be the most critical. High intelligence is not easily or effectively demonstrated without high verbal ability, which is simply the ability to understand and use one's language. Skill in reading, ease of self-expression, and a constantly expanding vocabulary characterize the child with high ability.

Verbal ability plays a doubly important role in that it is a trait possessed in large measure by teachers and psychological testers, two groups which are instrumental in identifying and evaluating superior students. Boys and girls with verbal ability are generally successful in school; they are able to express what they know with greater readiness than those who lack this skill. Indeed, Charles Broadley is probably correct when he points out that facility with vocabulary contributes more to success than any other single skill. There is some indication that verbal ability is partly the result of cultural influences. Children of parents with particular distinction in this respect tend to encourage their children to acquire a similarly well-developed verbal ability.[12]

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[10] Blizard, "Increasing the Effective Number of Women in Science," unpublished. See also Terman and Oden, *The Gifted Child Grows Up*, pp. 13–15; Wechsler, *The Measurement of Adult Intelligence*, pp. 108–109; Garrett and Schneck, *Psychological Tests, Methods, and Results*, pp. 198–201; Hottel, in American Council on Education, *How Fare American Women?*, p. 19.

[11] For a discussion on this point see Roe, *The Making of a Scientist*, pp. 156–157; Bray, *Issues in the Study of Talent*, p. 2.

What makes for good scientific ability? Here again we are dealing with a complex subject. First, there is reason to believe that scientific ability is a function of high general intelligence. Second, whether it is a special ability that is inherited or one acquired and nurtured through opportunities has never been clearly demonstrated. Third, it is easier to identify what accompanies scientific ability than to describe it itself. Scientific ability is linked with unusually good ability to handle spatial concepts, sound judgment, strong powers of inductive reasoning, a certain fluency of ideas, good memory, and a quality that might be called a special kind of stick-to-itiveness. The ability to be intellectually and emotionally self-reliant, or "inner-directed," to use Riesman's term, seems to accompany good scientific ability. Other than that, few people seem really to know what science ability is.[13]

Another term having relevance to intelligence is aptitude. Aptitude has been defined as "the possession of characteristics that make for success in an occupation." In a sense, it represents facility to acquire information or skill given certain conditions.[14] Here again whether aptitudes are inherited or acquired or both is not too clear. There is strong evidence that they are inherited. Charles Broadley has identified some 17 traits which he claims are the known aptitudes. They are personality, accounting aptitude, creative imagination, structural visualization, inductive and analytical reasoning, finger dexterity, tweezer dexterity, observation, memory for design, tonal memory, pitch discrimination, number memory, eye dominance, proportional appraisal, grip, visual imagination, and tapping![15] In time, no doubt, sociological and psychological chemistry will devise a whole periodic table of human aptitudes.

Against the background of this brief examination of intellectual superiority, there are several points which have a bearing on any plans to identify and encourage high-level ability in science among high school students. First, it is apparent that in the past the approach to ability has been too narrow. The very phrase Intelligence Quotient is a mechanical, technical, impersonal term. If wisdom were only knowledge, if insight, understanding, and ethical standards were as easily weighed as algebra and vocabulary, then IQ's would be more accurate measurements of giftedness. As A. H. Maslow has pointed out; Herman Goering had a high IQ but he was a very vicious, stupid man.

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[12] See Broadley and Broadley, *Know Your Real Abilities*, p. 161, 163.

[13] Brandwein, *The Gifted Student as Future Scientist;* Bloom, "Science Provisions for the Rapid Learner," *The Science Teacher*, vol. XX (Sept., 1953), p. 162; Brown and Johnson, *Education for the Talented in Mathematics and Science*, p. 2, 6.

[14] Super, *Appraising Vocational Fitness by Psychological Tests*, p. 67. See also Crawford and Burnham, *Forecasting College Achievement*, Part I, "General Considerations in the Measurement of Academic Promise," pp. 3–13.

[15] Broadley, *op. cit.*, p. 6.

Second, although information on psychological testing is accumulating at an enviable rate and although we are learning more and more about superior talent, the great need at present, as Douglas Bray has indicated, is for "the development of a theoretical framework."[16]

It has been repeatedly stated that we are suffering a loss in the utilization of high ability all along the educational line for a number of specific reasons. Some loss of talent is the result of a retarding of mental development through standardized school promotions. Some results from attrition, withdrawal from high school or college for financial, social, emotional, or personal reasons. Some results from what might be called diversion, occurring when the person of high ability goes into an occupation where his faculties will not be most fully employed. Considerable loss in the effective use of high talent appears to occur through deficiencies in the educational system itself.

A further point that must be considered is the influence of environment on the development of high ability. Although there is increasing evidence that mental qualities are inherited and that abilities and aptitudes are produced in the genes, we cannot underestimate the influence of economic and cultural forces on the performance of those abilities once they appear. In one study that has been made it was discovered that about 25 per cent of the children who enjoyed excellent cultural opportunities had IQ's of 125 or more while only 6 per cent of the entire population evidences IQ scores of 125 or higher. Research at the Columbia University Neurological Institute has shown that proper nutrition has a significant influence on the use of intelligence. The addition of glutamic acid and thiamin to the diet of children who had been undernourished was accompanied by increases in their IQ scores.[17] Ellsworth Huntington has suggested that diet and even climate profoundly affect mental activity.[18] A study made at the Child Welfare Research Station of the University of Iowa has revealed that children of mentally inferior mothers of low economic and social status, when placed in good foster homes at infancy and given care and good education, received above average IQ scores.[19] Good nutrition, a home life that is not uncomfortable or insecure, and parental encouragement should all assist in improving the performance of a child with promising ability.[20]

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[16] Bray, *Issues in the Study of Talent,* p. vii. See also the preface of Terman, *Genetic Studies of Genius.*

[17] In this connection it is interesting to note that David Krech, Mark Rosensweig, and Edward Bennett of the University of California have recently developed a theory that the difference between the brain of a genius and that of a person of average intelligence may be due to the enzyme cholinesterase.

[18] Huntington, *Mainsprings of Civilization,* p. 237, 343, 430.

Another observation about high-level ability which must give us pause is contained in the findings of Harvey C. Lehman, whose *Age and Achievement* amasses impressive evidence indicating that the peak period for outstanding accomplishments in many fields of endeavor comes toward the beginning of the adult years. He found that the years of maximum productivity for chemists are those between the ages of 26 to 30, for physicists from 30 to 34. Mathematicians have made their most notable contributions to knowledge between the ages of 33 to 37.[21] In studying 20 great inventions of modern times, Wyman has pointed out that the mean age at which they were made is 32.[22]

Although outstanding scientific accomplishment occurs at all periods of life, there are many fascinating examples of great achievement at a tender age. John Stuart Mill learned Greek at the age of 4. James Hillier constructed his first microscope as a boy. Newton spent his childhood making water clocks and windmill models. Pascal wrote his famous essay at 16, the great mathematician Karl Friedrich Gauss, after performing distinguished work at 15, developed his method of least squares at the age of 18. Sir Humphry Davy's first chemical discovery was made when he was 20, the same age at which Edmund Halley read his first paper before the Royal Society. James Joule at 21 enunciated the law which bears his name while Marconi at 21 sent his first wireless transmissions. Samuel Colt started working on the idea of the revolver at 16. At 19 George Westinghouse invented a device for replacing derailed cars.[23]

The age and achievement curves which Lehman has drawn represent the performance of not only geniuses but others and reveal more than accidental phenomena. They indicate that intelligence, after reaching its maximum peak early in adult life, begins its inexorable decline just as other bodily attributes do. Josef Brozek has reminded us that "from the age of 30 years onward a person's ability to understand new ideas, to adopt new methods of working, and even to adjust to new situations steadily decreases."[24] This sobering thought has prompted some to urge all the more strongly that the gifted be encouraged to accelerate in our schools. As Sidney Pressey has put it, "Efficient human engineering would seem to call for getting people into their productive careers early in this period of greatest potential productivity. . . . Full-time graduate and professional education has tended to extend so far into these precious young adult years that professional accomplishments may be seriously delayed."[25] In this connection, we might note that in the United States before World War II the median age at which graduate students received the Ph.D. was 33 while the median age for students in Germany was eight years earlier. Almost one-fifth of American doctorates were received by persons over 40. If Terman's thesis that the boy or girl with superior intelligence can learn the ordinary school subjects in half the normal time is correct, and if the greatest accomplishments in science are likely to be produced by persons in their late twenties and early thirties, it behooves us to examine carefully how leisurely we can afford to be with the education of the gifted.

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[19] Bray, *op. cit.*, p. 16.

[20] Trytten, in National Research Council, *Human Resources and the Fields of Higher Learning*, pp. iv–3; Stoddard, "Youth," *Scientific American*, vol. 185, no. 3 (Sept., 1951), p. 102.

[21] Lehman, *Age and Achievement*, p. 20, 134, 254.

[22] Wyman, "Age of Production in Invention and Other Fields," *Journal of the Patent Office Society*, vol. 1 (1919), pp. 439–437.

[23] For additional examples see Witty, *The Gifted Child*, p. 89; Lehman, *op. cit.*, pp. 180–183, 200–216.

[24] Brozek, "The Age Problem in Research Workers—Psychological Viewpoint," *Scientific Monthly*, vol. LXXII, June, 1951, p. 357.

It is logical to be concerned about the education of gifted children for they are the individuals who will contribute more than their share to the welfare of society. Such contribution cannot be forthcoming unless their abilities are developed through education. Thomas Huxley's admonition is worth repeating: "Now the most important object of all educational schemes is to catch these exceptional people and turn them to account for the good of society."[26]

However, recognition of such ability differences runs counter to popular opinion. Our tradition of political equality and of equality of opportunity has transcended into intellectual realms. Even in educational circles, concern for individual differences has been overshadowed by an emphasis on personality adjustment to a norm. Conformity in personality is a popular goal. But the well-adjusted individual, with no intellectual anxieties, no discontents, psychologists say, is likely to be complacent. There is no room for complacency in creativity. Paul Witty, Herbert Carroll, and others have questioned the desirability of prescribing conformity for intellectually gifted children. Carroll has declared, "It may well be that they should be encouraged in developing an extreme form of individualism."[27] A. H. Maslow's criticism of the educational job done for the superior child is probably justified. "The concept of the well-adjusted personality or of good adjustment sets a low ceiling upon the possibility for advancement and for growth. The cow, the slave, the robot may all be well adjusted." Several years ago Byron Hollinshead concluded that one of our most urgent goals was to create in public opinion an approval of differentiation in abilities and a recognition of what superior ability meant in terms of the public good.[28] Although some progress has been made, there is still need for more publicity on this point.

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[25] Pressey, "Time-Saving in Professional Training," *The American Psychologist*, vol. 1, no. 8 (August, 1946), p. 326.

[26] Quoted in Garrison, *The Psychology of Exceptional Children*, p. 201.

[27] Carroll, *Genius in the Making*, p. 170.

But how, it might be asked, can we identify this woefully small segment of our young population which will provide the essential leadership for our civilization in the future? Many elementary techniques can be employed. There are many different types of tests that serve to identify excellence, among them intelligence tests, aptitude tests, ability and achievement tests, tests to measure attitude, and tests of temperament, personality, projection, and perserverance. Even if tests can measure precisely whatever is measurable, what predictive accuracy do they have? The use of intelligence tests, alone, will not enable us to determine giftedness in many areas. Particularly in the identification of potentially creative powers in science (as well as in music and art), testing at the high school or early college levels appears to have severe limitations. David Wechsler has examined these limitations and has concluded that it is difficult to secure adequate measurements of abilities comparable to those needed by a Newton, a Faraday, or an Einstein.[29]

Despite these limitations, testing for scientific ability should begin early in order to encourage those who have scientific leanings. The Steelman Report concluded that the end of the tenth grade was a highly desirable time to use special tests to uncover high ability.[30] Dael Wolfle has suggested that a successful testing program could take place at the ninth grade level.[31] Others have proposed programs at an even earlier level. Henry Chauncey has stated that tests to identify high ability might be employed as early as the fifth grade.[32]

Although there is disagreement among psychologists as to just what qualities or abilities intelligence tests are supposed to measure, they are still our most satisfactory method for identifying our potential intellectual resources. The suggestion has been made that intelligence test results could be more serviceable if a distinction were made between three types of intelligence: genetic, developmental, and test intelligence.[33] In addition, tests which measure scholastic aptitude have a high predictive value. Indeed, C. Gilbert Wrenn has singled them out as being the best predictors of success in graduate study.[34]

Grades in school frequently have been cited as predictive measures of ability.

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[28] Maslow, *Motivation and Personality*, p. 376; Hollinshead, *Who Should Go to College*, p. 82.

[29] Wechsler, *The Range of Human Capacities*, pp. 96–97.

[30] Steelman, *Science and Public Policy*, vol. iv, p. 89.

[31] Wolfle, "Intellectual Resources," *Scientific American*, vol. 185, no. 3 (Sept., 1951), p. 44.

[32] Chauncey in Wolfle, *Human Resources; The Needs and the Supply*, p. 47.

[33] Eells, *Intelligence and Cultural Differences*, pp. 70–71; Witty (ed.), *The Gifted Child*, p. 14.

[34] Wrenn, "High Level Research Talent," in National Research Council, *Human Resources and the Fields of Higher Learning*, p. 11.

Useful though they may be there is a certain unreliability about them that is graphically illustrated in the table Wolfle includes in his study, *America's Resources of Specialized Talent*. In it he indicates that less than half of those with ability to score between 125 and 134 on the AGCT are in the top fifth of their high school graduating class and that only two-thirds of those with scores between 135 and 144 are found in the top fifth by school grades.[35] School grades reflect the subjective judgment of individual teachers to a certain extent and apparently certain types of personality reveal ability more easily to an elementary or high school teacher than other types. The "self-actuating," quiet, shy child is less likely to be noted with consistent frequency by schoolteachers than the more articulate, self-assertive type. Although good marks usually indicate good intelligence, there is wide room for error. Herbert A. Carroll has reported that the coefficient of correlation between intelligence and school achievement for elementary school children is approximately .60; for high school students, .50; and for college students, .45.[36]

More recently, Harrison Gough has studied achievement and the lack of it among intellectually gifted people and on the basis of psychological testing has described different personality patterns. Gifted students who succeeded in going to college were found to be industrious, patient, honest, and conscientious. Those who failed to enter college were characterized as autocratic, blustery, stubborn, and conceited.[37] Flanagan has also made careful study of the characteristics of superior persons. In summarizing his findings after interviewing 500 scientific and engineering researchers, he stressed the abilities to do well at the following tasks as ideal prerequisites for success in the field: formulating hypotheses, planning, developing, and conducting investigations, interpreting the results of research, preparing reports, administering projects, undertaking organizational responsibility, and accepting personal responsibility. Such studies throw interesting though limited light on the ideal personality qualifications for success in science.[38]

However, Thorndike, Lorge, Super, and others have come to the conclusion that at the present time psychological testing cannot adequately predict success in vocational life. Efforts to identify high-ability youth or children with promising scientific ability, therefore, must be carried out carefully so as not to shut the door on someone who for some reason failed to indicate his potential in a written examination. IBM cards and calipers should never check freedom of opportunity. Tests to identify intellectual superiority should be used to encourage children, but not to discourage them. Furthermore, the results of such tests should be supplemented by individual conferences if vocational guidance is to be effective.[39]

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[35] Wolfle, *America's Resources of Specialized Talent*, p. 316.

[36] Carroll, *Genius in the Making*, p. 163. See also Sumption in Henry (ed.), *op. cit.*, p. 263; Bristow in Witty (ed.), *The Gifted Child*, p. 18.

[37] See Gough, *Some Personality Differences between High Ability School Students Who Do, and Do Not, Go to College*.

[38] Flanagan, *et. al. Critical Requirements for Research Personnel.*

The limitations resulting from cultural bias in tests have been widely discussed during the last 20 years. Many psychologists have criticized intelligence tests for discriminating in favor of professional and middle-class children at the expense of those from lower-class homes. Children from homes that contain few books and meager cultural opportunities may have a greater difficulty answering the standardized tests than those whose socio-economic backgrounds have been rich in cultural and educational blessings.[40]

As a result of experimental study with pupils who were subjected to different tests, it has been possible to measure the relative importance of cultural background in test performance. It has also been found that family income and per capita expenditure on education correlate very closely with intelligence test scores.[41] Differences in economic and cultural background must be recognized in using nation-wide, standardized tests. However, it must also be remembered that, to some extent, the cultural bias in intelligence tests also exists in college entrance requirements. Consequently, there are grounds for concluding that a "culture-free" test would not serve as a completely accurate index of college aptitude.

The evidence on tests and their limitations suggests several cautions for anyone engaged in a nation-wide talent search. The more general the thing tested the better. General ability appears to be a more reliable index than specific abilities. Furthermore, we must be careful in our search not to exclude any of the gifted children through the operation of standard orthodox examinations. Gifted children, in particular, do not fit the ordinary rules. Some children with unusual talent do not respond to the typical testing situation; some are deficient in verbal skills and hence do not communicate to others all they know or could know. Because of their personality, emotional condition, motivation, or natural interests, some persons apparently cannot have their intelligence tested independently of these other factors.[42]

A few classic illustrations will indicate how hazardous is the identification of the gifted. Darwin's biographer pictured the scientist in his youth as "evidently a 'difficult' child, hard to arouse, slow to learn, seldom eager, a self-centered day-dreamer." He was also "a timid, stammering, nervous boy," "a sufficiently commonplace child" who, while in school, "was quite unexceptional, if among the rather more timid, the more gullible of his fellows." The account further adds, "Sensitive he most clearly was, but in these days much less certainly imaginative."[43] Thomas Edison's teacher called the boy dull, "if not actually half-witted," and he was put at the foot of his class. Because his first school report was so bad, his mother decided to tutor him at home. Even Einstein was called a slow learner as a child.[44] Tests and teachers can be fallible and it is well to recall Ramon y Cajal's observation, "Reality often takes pleasure in laughing at predictions and in blasting hopes."[45]

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[39] See Super, *op. cit.*, p. 124.

[40] Davis and Havighurst, "The Measurement of Mental Systems," *Scientific Monthly*, vol. LXV, April, 1948, p. 302.

[41] See *Ibid*, p. 315; Crawford, *Forecasting College Achievement, Part I*, "General Considerations in the Measurement of Academic Promise," p. 11; Eells, *Intelligence and Cultural Differences*, p. 4; Montagu, "Racial Intelligence," *The Scientific Monthly*, vol. LXVI, Jan., 1948, p. 81; Witty, *The Gifted Child*, p. 83.

[42] For additional consideration of this point see Davis and Havighurst, *op. cit.*, p. 316; National Manpower Council, *A Policy for Scientific and Professional Manpower*, p. 79; Lehman. *Age and Achievement*, p. 36; Stoddard, "Youth," *Scientific American*, vol. 185, no. 3 (Sept., 1951), p. 102.

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[43] West, Geoffrey [pseud.], *Charles Darwin, A Portrait*, (New Haven: Yale University Press, 1938), p. 46, 48, 50.

[44] Carroll, *Genius in the Making*, p. 250.

[45] Ramon y Cajal, *Precepts and Counsels on Scientific Investigation*, p. 169.

Scientific ability, its supply and demand

In preceding sections, it was suggested that, because of the increasing importance of science in the modern world, scientific talent has become an exceedingly precious commodity, the more so because of the hazards involved in its identification. Its value is especially apparent when one examines the supply and probable demand for scientific ability in our economy.

Much has been written recently about the supply and demand trends for persons of different specialized abilities. The most recent comprehensive work in this field is Dael Wolfle's *America's Resources of Specialized Talent.* Another recent book containing essays by a number of authorities on different aspects of the manpower situation is Haber, Harbison, Klein, and Palmer, *Manpower in the United States: Problems and Policies.* Older studies that contain valuable information on American economic growth are Jaffe and Stewart, *Manpower Resources and Utilization,* and Durand's *The Labor Force in the United States.* The work by Dewhurst and associates, *America's Needs and Resources,* published in 1947 and revised in 1955, cannot be ignored by anyone working in this field. Another recent study containing useful projections for 1960 is Jaffe and Carleton's *Occupational Mobility in the United States.* The several publications of the National Manpower Council, *A Policy for Scientific and Professional Manpower, Proceedings of a Conference on the Utilization of Scientific and Professional Manpower,* and *A Policy for Skilled Manpower* are also indispensable. Individual Bureau of Labor Statistics reports on particular occupations, *Employment, Education, and Earnings of American Men of Science,* for instance, frequently contain useful information. The various Bureau of the Census reports are also essential.

Since the end of World War II there have been countless articles in scientific and popular periodicals dealing with the manpower crisis. Several attempts have been made to draw up comprehensive bibliographies. Although limited to specific years, the most useful are Weislogel and Altman's *Abstracts of*

Literature Concerning Scientific Manpower and *Scientific Manpower,* the latter a bibliography on supply, demand, and utilization covering the years from 1940 to 1950, with a supplement for 1951 and 1952, that was prepared by the Department of Defense Research and Development Board.

One difficulty that is evident at the outset in a reading of this literature is the problem of definitions of terms. In speaking of the supply of high ability, do we refer to the handful of brilliant geniuses in our population, to those with doctoral degrees, or to those with some acquired or developed skill? What characterizes "specialized talent"? It has been pointed out frequently that the category called specialized or scientific or professional is much easier to illustrate than to define.[1] The lines between different categories are blurred and sometimes indistinguishable. Furthermore, much depends on whose definition one accepts. Who in our country is an engineer? Is it someone who graduated with an engineering degree from a recognized institution of higher learning, someone working in a firm or at a job identified as engineering in nature, or someone whose wife says he's one? Our systems of classification only add to the confusion for frequently they fail to take into account the recent changes in specialization and the appearance of new subject fields. These limitations must be kept in mind when one attempts to reconcile the widely conflicting estimates of the number of engineers or physicists or chemists in our society.

In addition, a further difficulty is posed by our changing concept of specialization. What was once a specialized skill might be considered unskilled or semi-skilled labor now. As Jaffe and Stewart point out, time and place have much to do with the hierarchy in any job classification.[2] The nature of the job required, the characteristics of the person performing it, or the complexity of the product or service involved are factors in continuous flux making it difficult to pinpoint with any precision the supply and demand to be studied. C. Gilbert Wrenn's observation is quite pertinent:

> "Anyone approaching the study of supply and demand with optimism is quickly and thoroughly disillusioned. There are no figures in any field that one can rely on with confidence. Even in such fields as medicine, pharmacy, and engineering where a great many facts have been collected, the estimates made are hedged around with many qualifications and warnings about the imponderables."[3]

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[1] For an extended discussion and definition of the different fields of specialization see Wolfle, *America's Resources of Specialized Talent,* pp. 10–23.

[2] Jaffe and Stewart, *Manpower Resources and Utilization,* p. 198.

[3] Wrenn, "High Level Research Talent: An Analysis of Supply and Demand Factors," in National Research Council, Office of Scientific Personnel, *Human Resources and the Fields of Higher Learning,* chap. 3, p. 1.

In looking at our present and future specialized manpower requirements the past can be very informative. Since 1870 a great transformation has occurred in the nation's labor force. Since that time the proportion identified as professional, technical, and kindred workers increased from 3 per cent of the labor force in 1870 to 6.7 per cent in 1940. They comprised 7.5 per cent of all employed workers in 1940, 8.8 per cent in 1953, and 9.4 per cent in 1954. Within that category, scientific and technological workers increased in numbers more rapidly than other groups. Representing only 3 per cent of professional workers in 1870, they formed 20 per cent of the group by 1950. Thus professional workers have been increasing in numbers three times as fast as the entire laboring force since 1870. Since that year there has been a fifty-fold increase in the number of engineers in our society. Persons employed in the natural sciences have increased from 1,300 in 1870 to 121,000 in 1950. The number of scientists has doubled almost every decade and the same is true for the engineering profession. Employment in the ranks of professional, technical, and kindred areas increased fifteenfold in this period. By 1953 the United States employed 5,370,000 professional and kindred workers of whom approximately 1,200,000 were engaged in science and technology.[4]

This phenomenal increase has not been constant. As might be expected, the rate of growth has risen in prosperous times. A particularly rapid increase can be seen in the last decade. There were 36,000 research workers in the nation's industrial laboratories in 1940. By 1950 this figure had jumped to 70,500. Expenditures for research and development in science and engineering increased from under one billion dollars in 1941 to 3.75 billion in 1952. There were 60,000 chemists in 1940. Ten years later there were 85,000. The number of physicians in the country increased from 175,000 in 1940 to 203,000 in 1950. The 1940 census listed 261,000 engineers and a decade later 534,000 were reported, although this figure is considered somewhat high by a number of authorities. The 1950 census listed 154,000 persons as natural scientists, including university and college teachers of science. Using a more inclusive definition of the term, Dael Wolfle estimated that there were 237,000 natural scientists and 633,000 engineers employed in 1953. This latter figure, however, is considered too high by several other groups responsible for tabulating the number in the profession. From the information available for 1955 we estimate there are between 535,000 and 650,000 engineers and between 225,000 and

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[4] For additional statistics see Durand, *The Labor Force in the U.S.*, p. 19; Jaffe and Stewart, *Manpower Resources and Utilization*, p. 194; National Manpower Council, *A Policy for Scientific and Professional Manpower*, pp. 42–46; United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *Manpower Resources for National Security*, part IV, p. 22, 23; Bowerman, *Studies in Genius*, pp. 49–50; United States Department of Labor, Bureau of Labor Statistics, *Fact Book on Manpower*, p. 54.

245,000 scientists who are currently employed throughout the United States.[5]

Wolfle's study provides estimates for other professions.[6] In 1953, it appears, there were approximately 212,000 physicians, 202,000 of whom were active in some kind of medical work. This compares closely with the figure of 214,000 which the National Manpower Council estimated for 1952.[7] According to the Defense Mobilization Committee on Specialized Personnel, there was to be a "deficit" of approximately 22,000 physicians for the year 1955.[8] The Wolfle study estimates approximately 84,000 active dentists for 1953. This is very close to the Defense Mobilization Committee's estimate of 80,000 for 1950.[9] A shortage has been predicted here as well. In another medical field, nursing, a shortage is also apparent. There were approximately 340,000 nurses in active practice in 1953. The Defense Mobilization Committee identified a minimum need of 404,500 for 1954. Because of the high marriage rate among nurses, the profession loses about 6.5 per cent of its active members annually. About 30,000 graduate into the profession each year but more than half of them leave active practice within three years.[10] It is clear that the shortage in this field will continue for some time. The figures given by Wolfle for the Commission on Human Resources and Advanced Training are equally discouraging in regard to the teaching profession. Although there are over a million teachers active at the present time, almost 100,000 are working on temporary certification. This is one gauge of the extent of the present shortage which quantitatively and qualitatively has reached fabulous proportions. During the next four years an annual deficit of at least 60,000 teachers will be added to our current shortage. Obviously, it will be impossible to meet all of these critical shortages.

If there are shortages at the top levels of our nation's scientific and professional ranks, what about the situation at the technician or skilled supporting level? The significant role played by this segment of our working force is no more fully treated than in the National Manpower Council's recent study, *A Policy for Skilled Manpower*, which is particularly useful in examining trends in skilled and technical manpower and in making recommendations for its more effective training and use. Of the eight or nine million skilled workers in the labor force there are about 400,000 technicians who work directly with scientists and engineers. These workers whose jobs require some formal type of training are frequently classified as semi-professional. They are the laboratory assistants, engineering aides, draftsmen, medical technicians, and surveyors whose economic role has been described as follows:

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[5] See Trytten, "Scientists," *Scientific American*, vol. 185, Sept., 1951, p. 72; United States Office of Defense Mobilization, Committee on Specialized Personnel, *Resources and Requirements of Specialized Personnel*, p. 20, 32, 67; National Manpower Council, *op. cit.*, p. 162; Wolfle, *op. cit.*, p. 80, 96. The Committee on Manpower Resources for National Security estimated the number of employed engineers in 1953 at 500,000. See also Wolfle, "Future Supply of Science and Mathematics Students," *The Science Teacher*, vol. XX, no. 4 (Sept., 1953), p. 158.

[6] Wolfle, *America's Resources of Specialized Talent*, pp. 75–136.

[7] National Manpower Council, *op. cit.*, p. 220.

[8] United States Office of Defense Mobilization, Committee on Specialized Personnel, *op. cit.*, p. 66.

[9] *Ibid.*, p. 67.

[10] *Ibid.*, p. 75.

> "Most technicians perform tasks which either were at one time, or still continue to be, within the range of the functions of professional personnel. Many of them work in a direct, supporting capacity to professional persons and scientists. The qualities peculiar to technicians are said to rest upon a combination or blend of two elements: some of the theoretical knowledge associated with a profession, and skills which are manual or involve the use of instruments."[11]

A technician's contribution tends to be mechanical rather than creative, manual rather than mental, although many technical assignments require someone with relatively high intellectual abilities. Frequently, technicians operate as members of research or industrial development teams. Sometimes they might be described in Richard Livingstone's terms as someone "who understands everything about his job except its ultimate purpose and its place in the order of the universe."[12]

Rapid growth characterizes many technical fields today, and increases since 1940 have been particularly marked. Shortages of engineers, industrial chemists, and others have served to intensify the demand for technicians. Indeed, there was a greater relative growth in the 1940's in the employment of technicians than in the employment of professional personnel. From 1940 to 1950 the number of technical workers in industrial research laboratories increased by nearly 150 per cent. For all types of technicians the average increase amounted to 102 per cent. By 1950 there were 10 technical workers for every 17 professional workers in the labor force.[13]

Since it is more elastic in its response to changing economic conditions, the technician group in the labor force is on the whole relatively easier to expand than the few trained geniuses in our population or the number of scientists and engineers. Higher wages resulting from personnel shortages will attract persons who, because of the limited nature of their scientific abilities or education, would be unavailable at the Ph.D. level. Nevertheless, crucial shortages in certain technical fields appear to exist and any changes in military demands will be immediately felt in this segment of the labor market. It is also well to bear in mind the generalization made by the National Manpower Council that advances in technology serve to increase rather than decrease the overall demand for skills.[14] The Department of Labor has stated and documented the fact that "technicians have an important part in strengthening America's technical and military position . . . the long-term outlook is for expansion in their employment."[15] Indeed, the work of some technicians is almost as vital to our industrial system as that of our top-notch scientists.

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[11] National Manpower Council, *A Policy for Skilled Manpower*, p. 51.

[12] Quoted in Maslow, *Motivation and Personality*, p. 21n.

[13] United States Department of Labor, Bureau of Labor Statistics, *Employment Outlook for Technicians*, Bulletin no. 1131, p. 14.

In connection with the recent increases in the proportion of professional, technical, and kindred workers in the labor force, it is significant that some of this increase has been due to the entry of women into certain scientific fields. The percentage of women in various professional fields has increased to the extent that they now account for about one-third of all professional and technical workers. Although women still constitute a small minority of those in the scientific professions, the proportion of scientists who are women has been rising faster than the proportion of women receiving bachelor's degrees.

The rapid rate of growth of the scientific professions that was previously mentioned is perhaps best reflected in the educational statistics of the last 50 years. The numbers attending college, receiving bachelor's degrees, and earning doctoral degrees and doctoral degrees in science have increased phenomenally. We have been undergoing an intellectual revolution in our society the complete results of which have yet to be seen. In 1900 only 25,000 bachelor's and first professional degrees were awarded in the United States, which then had a population of 76 million. Only 1.7 per cent of 22-year-olds were college graduates that year. In 1920 the corresponding figure for degrees awarded had almost doubled while the population had grown to 106 million. By 1940, out of 132 million Americans, 186,500 were awarded bachelor's and first professional degrees and college graduates that year amounted to 8.1 per cent of the 22-year-olds. In 1950, after large numbers of World War II veterans had flocked to the campus, the number of first degrees awarded had shot up to 434,000. In 1953, the number dropped to 304,857. Table 3 illustrates the rapid increase in enrollments during the last 25 years.

Table 4 illustrates the growth in the total number of doctoral degrees earned over the last 80 years as well as those in the field of the natural sciences. The number earning doctorates in the sciences has grown from about 100 in 1900 to 3,800 in 1954. It is noteworthy to observe that the number earning science doctorates annually has increased 20 times as fast as the total population and the labor force. Over the years about 55 per cent of all earned doctorates have been

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[14] National Manpower Council, *op. cit.*, p. 56.

[15] United States Department of Labor, Bureau of Labor Statistics, *op. cit.*, p. 1.

TABLE 3

COLLEGE ENROLLMENTS *and first degrees awarded, 1930–1954*[a]

	College enrollments		*Bachelor's and first professional degrees awarded*		
	Total	*Men only*	*Total*	*Men only*	*Engineering only*
1930	1,101,000	620,000	122,000	74,000	7,700
1940	1,494,000	893,000	187,000	110,000	15,100
1950	2,269,592	1,569,322	434,000	330,000	52,000
1953	2,250,701	1,432,474	304,000	200,000	24,000
1954	2,499,750	1,601,984	292,000	187,500	22,000

[a] Sources: United States Department of Health, Education, and Welfare, Office of Education, *Fall Enrollment in Higher Educational Institutions, 1954;* United States Department of Labor, Bureau of Labor Statistics, *Fact Book on Manpower;* United States Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1954.*

TABLE 4

EARNED DOCTORATES *awarded, 1880–1955 (estimated)*[a]

	All fields	*Science fields*
1880	45	
1890	135	
1900	239	102
1910	362	180
1920	565	330
1930	2,079	1,055
1940	3,020	1,756
1950	6,376	3,290
1952	7,683	4,200
1953	8,309	3,684
1954	8,996	3,811
1955	8,840	3,700

[a] For a comprehensive examination of the accuracy of various sources of data on doctoral degrees see Scates, Murdoch, and Yeomans, *The Production of Doctorates in the Sciences, 1936–1948,* pp. 16–20, 24–28.

in the fields of science. In 1953, the proportion was close to 45 per cent, and 50 per cent if doctorates in engineering are included.[16]

Although these figures are impressive, there may be some significance in the fact that the percentage of college students majoring in the sciences has been decreasing over the years. In 1900, one-quarter of all bachelor's degrees were in science fields. Of the college graduates examined by Havemann and West in their 1952 study, 15 per cent majored in the sciences.[17] Dael Wolfle estimates that in 1950 only one-eighth of the college graduates majored in a science.[18] In

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[16] See Scates, Murdoch, and Yeomans, *The Production of Doctorates in the Sciences, 1936–1948,* p. 39, 43; United States Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1954,* p. 109.

[17] Havemann and West, *They Went to College,* p. 8.

[18] Wolfle, "Future Supply of Science and Mathematics Students," *The Science Teacher,* vol. XX, no. 4 (Sept., 1953), p. 159.

1953, about 10 per cent of the college graduates seem to have been science majors. The low point in the production of science graduates will probably come in 1957–58.

The proportion studying engineering, however, is increasing after having dropped. In 1900 about 4 per cent of the total bachelor's and first professional degrees were in the field of engineering. After World War I the proportion fluctuated between 7 and 10 per cent. In more recent times about 10 per cent of the college population have been engineering students. In 1953, less than 8 per cent of all bachelor's and first professional degrees were in engineering.[19] Historically, 2.9 per cent of all high school graduates have gone directly into engineering schools.[20] The sharp decline in the number of engineering students since 1948 has been discussed at length in other works. The trend now, however, is in the opposite direction. In 1952, for instance, the total college enrollment of men increased 15 per cent over the previous year while the freshman engineering enrollment increased 30 per cent.[21] Henry Armsby has pointed out that from 1950 to 1953 the total number of college freshmen increased 11 per cent while the number of freshmen studying engineering went up 76 per cent. In 1953 pre-engineering freshmen entering college made up 10.5 per cent of all new students and in 1954, 10.3 per cent.[22] The number of engineering graduates in 1955 was approximately 22,000. It may reach 30,000 in 1956 and 35,000 by 1964. It has been suggested, however, that a good deal of the increase in the number of engineering students may be at the expense of the natural science fields.[23]

In looking toward the impending "tidal wave" of college students, it would be realistic to anticipate that the proportion studying science and engineering will decline somewhat. By 1965, perhaps only 7.5 per cent of the degree recipients will have majored in the natural sciences and about 8.5 per cent in the field of engineering. Remembering that less than half of those earning degrees in the natural sciences and about nine-tenths of those with degrees in engineering enter professional employment in their respective fields, and also in view of our anticipated demands for personnel in these categories, we can well ask whether we can rely on getting as many as we will need or whether we must change the base out of which this supply must be produced.

One vital factor bearing on this question is the exact extent of the anticipated increase in college enrollments in coming years. Reasonable estimates have predicted enrollments in 1965 two and one-half times larger than the 1939 figures. Twice as many high school graduates will try to get admitted to college in 1970 as in 1954. The number of college graduates in 1960 is likely to be at least 325,000; in 1965, between 450,000 and 475,000. It has been conservatively estimated that some 6,600 doctoral degrees should be awarded in 1960 and almost twice that number in 1970.[24]

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[19] Wolfle, *America's Resources of Specialized Talent*, p. 292; United States Department of Health, Education, and Welfare, Office of Education, *Earned Degrees Conferred by Higher Educational Institutions 1952–1953*, p. 16.

[20] See Trytten in Wolfle *et al.*, *Human Resources; The Needs and the Supply*, p. 59.

[21] National Manpower Council, *A Policy for Scientific and Professional Manpower*, p. 175.

[22] Armsby, "Scientific and Professional Manpower, Its Supply and Utilization," *Higher Education*, vol. XI, no. 2 (Oct., 1954), p. 24.

[23] Wolfle, "Future Supply of Science and Mathematics Students," *The Science Teacher*, vol. XX, no. 4, (Sept. 1953), p. 159.

It might be thought that these marked enrollment increases will in themselves insure sufficient national supplies of scientists and engineers. However, the Commission on Human Resources and Advanced Training estimates that only about 42 per cent of those receiving degrees in natural science will enter upon scientific careers. And although the proportion for engineering graduates is much higher, the shortage of engineers will continue at least until 1960. Moreover, it seems that shortages in one field can now be made up only at the expense of other fields—for example, increases in the number of engineers will result in fewer natural scientists, and increases in numbers of both scientists and engineers will probably aggravate shortages in teaching or other professions. This is one reason why overall forecasts of the future supply of trained manpower predict continued acute shortages. Another reason is that losses through death, retirement, and occupational changes will also drain our meager supply, offsetting to an extent the numbers of newly-trained replacements. The National Manpower Council has estimated that fully 30 per cent of all those who were active in the professions in 1950 will have left the working force by 1960, that one-half of the nurses and about 70 per cent of the teachers will no longer be working in their specializations by then.[25] The turnover and loss of research engineers and scientists per year has been estimated at about 16 per cent.[26]

Despite predictions of continued shortages of trained manpower there has been some concern expressed lest we face an overproduction of college graduates. The dire forebodings of Professor Seymour Harris have been widely quoted and widely criticized. In *The Market for College Graduates*, published in 1949, Harris estimated that there might be over 10.6 million college graduates in the United States by 1968. Since he could foresee only four million professional jobs available for them, he predicted severe unemployment among college graduates. He believed that the resulting economic frustration might lead to intensified totalitarian movements among the nation's younger intellectuals. Prior to the Korean War, the Bureau of Labor Statistics issued similar cautions about the nation's growing supply of educated persons. Even James B. Conant has been quoted widely as voicing fear that we might educate more for the professional classes than our economy could support.

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[24] One careful study projecting recent trends has estimated that 13,000 doctoral degrees will be awarded in 1960 and 36,000 in 1970. See Scates, Murdoch, and Yeomans, *op. cit.*, p. 24, 33. For more conservative estimates, see Wolfle, *America's Resources of Specialized Talent*, p. 43, and Bowles, "The Future Supply of Scientists," *The Educational Record*, vol. 35, no. 3 (Aug., 1945), p. 109.

[25] National Manpower Council, *op. cit.*, p. 60.

[26] Griffing, "Selective Service Policy in Training and Utilization of Specialized Personnel," in American Association for the Advancement of Science, *Third Conference on Scientific Manpower*, p. 13.

It is true that in some fields—in law, journalism, and certain areas of the social sciences—supply has exceeded demand in recent years. At the same time, the Harris prediction seems to assume a relatively static economy and a rather limited future demand for college graduates. But our economy is proving to be dynamic, not static. And future technological developments will probably result in relative increases in the demand for skilled workers rather than technological unemployment.[27] The greater complexities of our machines require smarter, better-trained technicians. As a recent governmental report put it: "Both military and civilian activities have become more technical, requiring a greater proportion of highly trained personnel. The expanding pattern of research and development becomes progressively more demanding of intellectual capacity, exceptional talent, and lengthy preparation on the part of a larger percentage of our population."[28]

Insofar as scientific manpower is concerned, there seems little likelihood that our supply could catch up to our demand in the next few decades. The pressures of the Korean engagement on our supply of specialized talents revealed how quickly surpluses of brains and material could disappear. M. H. Trytten has eloquently indicated how foolish it would be for us to underestimate our need for trained specialists in another conflict.[29] And after weighing the elusive statistics of supply and demand Dael Wolfle has concluded that, considering the welfare of the nation as a whole, it would be better to overestimate our demand and underestimate our supply because it takes too long to make up a deficit after it has been identified, while a surplus can be profitably put to use in a variety of ways.[30] This suggests that, regardless of the Harris thesis, a broad educational foundation should be provided in the training of our scientists, doctors, and engineers in order to insure them optimum flexibility in their future careers.

Reviewing what has been written about the anticipated demand for specialized personnel, as we shall do below, justifies the Wolfle view rather than the more pessimistic Harris one. Before we examine some specific demand projections in detail, however, we should consider various assumptions on which demand estimates are based. The word "demand" can be defined in many ways. It may mean the number of persons actually needed by society irrespective of cost, the number that the public or some authority thinks is needed, or the number society can afford. In economic terms it may refer to the number of persons "marketable" at a particular price. A strictly economic interpretation, however, leaves little leeway for what might more accurately be considered a "requirement" rather than an expressed "demand." Military or national health requirements might indicate a need that could not ordinarily be provided for by the economy. A few years ago an inconclusive battle raged over estimates of how many doctors were needed in the United States. The estimates varied widely because different assumptions regarding "demand" were made by their authors.

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[27] See Haber, Harbison, Klein, and Palmer, *Manpower in the United States: Problems and Policies*, p. 106, 111.

[28] United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *Manpower Resources for National Security*, part V, p. 2.

[29] Trytten, *Student Deferment in Selective Service*, p. 20.

[30] Wolfle *et al.*, *Human Resources*, p. 19. See also Millett, *Financing Higher Education in the United States*, pp. 46–47; United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *op. cit.*, part IV, p. 28.

Another reason why estimates of future demand vary considerably is that different assumptions are made about the future trend of productivity. Projections made seven and eight years ago seem overly conservative now, partly because it had not been expected that our rate of productivity would continue to increase as rapidly as it has. According to Jaffe and Stewart, there is good reason to believe that this trend will accelerate even more in the future.[31] As John Hilliard has declared, "Our economy is going to keep on expanding. The dynamics which have characterized it for 200 years continue unabated. . . . It must if we are to have national security."[32]

To evaluate future guesses about our demand one must also take into account what priority has been given to the many competing needs expressed in our society. Is the demand for teachers as crucial as the demand for doctors? If so, will society recognize it as such and increase teachers' salaries? To be completely honest, any forecaster must reveal his biases for certain fields as well as his general assumptions. Obviously, if we assume that our economy will continue to expand, that the international scene will continue to produce a series of solvable crises, and that the nation's standard of living will continue in the direction it has taken in the past, our estimates of future demand will be much greater than if we start with the assumption that a depression or a more secure peace are right around the corner.

There are still other imponderables involved in making manpower demand predictions. Some of the relevant information on which to base future estimates is secret or restricted. Forecasting military requirements for specialized personnel is particularly hazardous. Even the economic concept is an elastic one, for it is difficult to say what kinds of work society might be willing to pay for in the future; the quality of the commodity dealt with can make a mockery of numbers. Moreover, demand is not only a quantitative matter; the expansion and direction of specialization have a direct bearing on it. And despite whatever skills society is willing to pay for or feels that it needs, variations in demand will have little effect on that portion of the manpower supply that is inflexible. For instance, high school graduates who lack the funds to go to college in the first place cannot very well respond to increased salaries offered for highly trained scientists.

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[31] Jaffe and Stewart, *op. cit.*, p. 241.

[32] Hilliard in American Association for the Advancement of Science, *Third Conference on Scientific Manpower*, p. 25. For another optimistic prediction see Harrison, "The Role of the Secondary School in the Teaching of Science," *Physics Today*, vol. 5, no. 6 (June, 1952), p. 12. The National Manpower Council, *op. cit.*, p. 244, has estimated an annual gain in productivity of about 3 per cent a year. The standard of living in the United States has apparently doubled since 1900. On the other hand, it has been discovered that per capita industrial production in 1954 was only 1 per cent above the average figure for 1947. United States Patent Office statistics reveal that the patent rate in the country has been decreasing for the last two decades. See Blizard, "The Future of Discovery and Invention," *Technology Review*, vol. LVI, no. 8 (June, 1954), p. 395.

Another imponderable in forecasting manpower needs is that we cannot foresee what major inventions will be made and what major new industries will arise in the somewhat distant future. Who after the Civil War could have envisaged the industrial might of this nation today? Who but a Jules Verne could have visualized sonar 70 years ago? Who in the depths of the Great Depression could have advised his son to study the atom or become a chemical engineer? Who today is seriously concerned about the probable shortage of astronomers the earth will face if and when inter-planetary travel becomes a reality? We cannot measure what we do not know. It requires considerable emancipation to peer into the misty future.

What all this means is simply that there cannot be much agreement nor much precision about future demands. It may well be impossible both to estimate what we will need in certain categories of skills and to ascertain which particular intellectual abilities will be most crucial to the nation or to the world 10, 20, or 50 years hence. Indeed, Dwight Chapman has suggested that the less we know about future demands the larger they are likely to be. On the basis of the uncertainty expressed by experts on all sides, it seems valid to assert that our demand for highly trained intellectual ability in the future will be much greater than we now realize and probably greater than we can satisfy.[33]

Despite these inherent sources of uncertainty, however, various techniques are being developed to improve the accuracy of estimating specialized manpower needs, particularly over short periods of time. In its October, 1950 issue, the *Journal of Engineering Education* described a possible method for measuring the demand for engineers based on correlations of this demand with some 11 different indices. In these various correlations, consumer price index, national income, and government non-war spending appeared to be significant factors.[34] The National Bureau of Economic Research has made some progress in its efforts to study theories and methods of forecasting. In one such effort, the validity of predicting the future demand for engineers on the basis of industrial research expenditures was investigated. Working along related lines, the Bureau of Labor Statistics is studying the factors that determine the amount of research done in industry.

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[33] For other considerations of this point see Chapman in Wolfle, *Human Resources*, p. 22; Trytten, *op. cit.*, p. 33; United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *op. cit.*, part IV, p. 2; Moe, "The Shortage of Scientific Personnel," *Science*, vol. 105, Feb. 21, 1947, p. 195. For a discussion of some other imponderables see Wrenn, "High Level Research Talent," in National Research Council, *Human Resources and the Fields of Higher Learning*, chap. 3.

Statistics on a variety of trends in the national economy, especially in industry, have been studied and used in forecasting future demands for scientists and engineers. For instance, productivity per industrial worker is commonly cited in such forecasts because it determines in part how much effort may be devoted to research and the service professions. Something of its effect may be seen in the fact that the horsepower available per industrial worker almost tripled in the first 40 years of this century, rising from 2.2 in 1899 to 6.4 in 1939.[35] Other significant trends used in demand forecasts are derived from such sources as census data, figures on gross corporation income, and reports of government research expenditures.

This latter factor, government-supported research, looms so large on the current scientific manpower scene that it merits special comment. In 1930 the federal government spent 23 million dollars on scientific research; in 1940, 67 million; in 1953, 2.2 billion. Today, military considerations play a role of the first magnitude in determining future demand. Not only do military needs decide the course of much of our current research; their increasing pressure contributes to the accumulation of projects which the nation must postpone for the time being. In 1953 government funds represented 60 per cent of the nation's total expenditures for research and development—and this 60 per cent represented a sum equivalent to over 20 dollars per person in the nation. In 1955, it has been estimated, half of the total research and development potential of the United States is engaged in atomic energy and aerodynamic studies for national defense. Even though research personnel has been found to increase only half as rapidly as increases in research expenditures, it is evident that this trend toward increased government support will strongly influence the supply and demand picture, particularly in view of the fact that between one-fifth and one-quarter of the country's scientists and engineers are actively engaged in research. Industrial support for scientific research is also rising, having doubled between 1949 and 1952. When more is known about the complex factors involved in stimulating research expenditures, we should be able to estimate demand for specialized manpower more precisely.[36]

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[34] See Wallace, Case, and Bolter, "A Possible Technique for Determining the Relationship Between Certain National Indices and the Demand for Engineers," *The Journal of Engineering Education*, vol. XLI, no. 2 (Oct., 1950), pp. 95–100.

[35] Jaffe and Stewart, *op. cit.*, p. 252.

Practically all the manpower estimates computed with techniques based on such economic indices and trends as these suggest an increasing demand for persons with scientific skills. For instance, the need for electrical equipment throughout our industrial economy will probably be so great, one expert has estimated, that just as much of it will have to be produced in the next 10 years as was made over the last 75. This will obviously require a concomitant rise in the number of men supervising its development and manufacture. Inasmuch as scientific research activity is increasing rapidly, the general demand for research scientists and engineers will probably continue to go up as well.[37]

Turning now to published estimates on future demands, we find the following: according to the Bureau of Labor Statistics we need annually at least 25,000 persons with bachelor's degrees in the natural sciences; add the requirements for engineering and the health professions and the figure is about 66,000. An annual enrollment of at least 110,000 male freshmen would be needed to produce this number. Other estimates are even higher. By March of 1954—a year in which only 22,000 bachelor's degrees in engineering were awarded—the demand in industry, government, and education amounted to 40,000 new engineering graduates. There is some evidence that the 1955 figure was about as high. One study in 1952 discovered that industrial research laboratories wanted to increase the number of scientists and engineers in their employ by 10,000. It has been estimated that the atomic industry alone will require between 10,000 and 20,000 additional scientific specialists in the next decade.

It has already been indicated that there are conflicting estimates of how many doctors we need. The extent of medical care expected, the methods of paying for it used, and the level of health assumed all bear directly on the estimates made. In 1949 the Health Resources Advisory Committee figured that the nation would need 210,600 doctors in active practice before 1955 and that, by 1960, 223,000 would be required. By that time, it predicted, the shortage of doctors would range between 22,000 and 45,000. But this estimate did not take into account any raising of the nation's standards of health or medical care. The expectation for the nursing profession is that the current shortage of 50,000 nurses may well grow to a shortage of 100,000 by 1960. In 1954 one-third of all nurses' positions in hospitals in New York State were vacant. The current serious deficit of teachers at all educational levels may never be diminished; in the teaching profession, every year from now on, according to one estimate, this nation's supply will drop behind demand by 60,000. According to Professor Fletcher Watson of Harvard University, the shortage of teachers by 1966 may well exceed 520,000. It seems apparent that during the next decade three new elementary and secondary schoolteachers must be found for every two who are now teaching. The shortage of college teachers will be equally acute. As for technicians, it is safe to assume that demand will remain consistently high. As more discoveries are made and more applications of scientific knowledge are successfully employed, the need for technicians to turn the wheels of industry will increase.[38] To make matters worse, the increase in the population in the next 20 years will aggravate the problem. Growing from 165 million in 1955 to 177 million in 1960 and to approximately 220 million in 1975, America will need an ever-increasing number of doctors and nurses, teachers and engineers just to hold its own.

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[36] For additional details on this subject see National Manpower Council, *op. cit.*, p. 12, 105, 110, 113, 198; Cohen, Paul, "Investing in the Future," *Technology Review*, vol. LVI, no. 8 (June, 1954), p. 405; Wolfle, *America's Resources of Specialized Talent*, p. 78; Coleman and Zalken, "Growth of Research Feeds Industry," *Aviation Week*, vol. LVI, no. 8 (Feb. 25, 1952), p. 48.

[37] See American Association for the Advancement of Science, *Third Conference on Scientific Manpower*, p. 8, 27.

So far, we have been considering estimates of the measurable demand that are based on a continuation of current conditions. One question on which there is apparently little information is the anticipated demand that can be expected five or 10 years hence for scientifically trained persons in what are traditionally considered non-science fields. Executive or administrative positions in certain areas of industry seem to be assigned more and more frequently to those with scientific backgrounds. If this industrial trend continues, and if more positions in the governmental matrix are manned by men of science, a severe drain on the scientific professions is likely to result.

Little has been said about the possible effect of United States military policy on the future demand for scientists and engineers. Drastic increases in military needs or commitments would obviously create a serious increase in the demand for technical personnel at a time when the supply would have certain inelastic qualities. The following observation is well taken:

> "About 45 per cent (340,000) of all our natural scientists and engineers are already employed in the metals, chemicals, and rubber industries, the precise industries that would feel the greatest impact in full mobilization. Another 160,000 are employed in federal, state, and local activities, 75,000 in educational institutions, and 175,000 in all other industries. Thus, while a significant shift from less essential to urgent defense activities could be effected, the great ma-

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[38] For more detailed data see Armsby, *Scientific and Professional Manpower*, p. 10; United States Office of Defense Mobilization, Committee on Specialized Personnel, *op. cit.*, p. 13, 21, 27, 67, 76; National Manpower Council, *op. cit.*, p. 103, 171–2, 232; Wolfle, *op. cit.*, p. 77; United States Department of Labor, Bureau of Labor Statistics, *Employment Outlook for Technicians*, Bulletin 1131, p. 14.

jority of scientists and engineers are now employed in activities which would have to be maintained or expanded during full mobilization. Furthermore, in many of the most critical specialities—including nuclear physics, electronics, and aeronautical engineering—a large proportion of personnel is already engaged in defense activities. Thus, while conversion of specialized personnel from nondefense to defense work is the primary means by which critical shortages must be met, it is at best only a partial answer to the problem."[39]

Additional military pressures on demand are likely to be felt even in peacetime. It is logical to expect that trends in the military establishment will parallel trends in industry and that a larger and larger percentage of its personnel would consist of, if not professional, at least technical and kindred workers. As more powerful weapons are developed, as the numerical strength of the infantry forces is reduced, and as our armed forces become more and more mechanized with more and more commitments throughout the world, the ratio of scientists and engineers in uniform to other military personnel is bound to increase.

All things considered, we can only conclude that every scientific and technical field will probably have an insufficient number of college and university graduates entering it for some time. The testimony of experts corroborates this at almost every turn. The National Manpower Council has concluded that there are no clear-cut ways to increase the number of top creative minds, and that even if there were, the demand for them is practically insatiable.[40] The Council's recent conference on the utilization of scientific and professional manpower found general agreement among its participants that it was impossible for the nation to have too many trained persons. In the long run, it was contended, we need a continuous increase in the number of our scientists and engineers.[41] The Committee on Manpower Resources for National Security has taken a similar position: "The margin of skilled manpower for expanded war production is extremely narrow in the light of modern requirements. . . . Altogether, it appears that continuing shortages of personnel can be expected in many professional fields, including those specialities of the most direct importance to the national defense."[42] Dean J. Douglas Brown of Princeton recently emphasized the need for meeting the nation's requirements for additional scientific personnel when he wrote:

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[39] United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *op. cit.*, part IV, p. 28.

[40] National Manpower Council, *A Policy for Scientific and Professional Manpower*, p. 196.

[41] National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, p. 91.

[42] United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *op. cit.*, part III, p. 10; part IV, p. 28.

> ". . . it is difficult to avoid the assumption that the creative stages of the mass-production cycle will remain under unusual pressure. . . . Since the only safe course is to assume a long-continued though variable pressure on the manpower resources needed in the creative stages of the mass-production cycle, it is important that steps be taken to compensate that pressure by adequate supplies. . . . The government of the U.S. should assume clear-cut leadership in educating the American public concerning the vital need for a sustained flow of manpower into the creative fields. Such a flow is a brutally evident necessity in an economy of hot war or cold war."[43]

There are several conclusions which these figures and estimates suggest. First, one cannot help but be impressed by the significance for our society, our economy, and our security of a continued adequate supply of trained persons in an increasing number of specialized fields. Nor can we fail to be struck by the immensity of the impending crisis resulting from our severe shortage in several areas. President deKiewiet of the University of Rochester has eloquently stated, "We can no longer afford to waste or neglect available resources of human skill. It has suddenly become clear that as a nation we are still too casual, too inexpert, too wasteful in our attitude towards brains and ability."[44] It is imperative that we face up to the shortages now existing in the scientific fields, in the teaching profession, and in other areas and that we attempt to meet the great demands likely to be felt in the near future.

As a nation we are just beginning to realize some of the social costs of the Great Depression and of the two World Wars we have fought. The most serious result of the paralyzing depression that rocked our economy from 1929 into the 1930's was probably the decreased birth rate which is now apparent in the shrunken ranks of our young adults, the age group of those now in their early twenties who are approaching their years of optimum achievement in creative activity. Society will suffer because there are not more of them to carry the load of an expanding, complex industrial system. Similarly, it has been estimated by the American Institute of Physics that World War II resulted in a deficit of approximately 17,000 doctoral degrees in the engineering and scientific fields. Although some of that deficit has been made up, our intellectual productivity is still lower than it should be, partly because of our policies during the war.[45]

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[43] Brown in Haber *et al.*, *op. cit.*, pp. 194–195.

[44] deKiewiet, "Implications for Higher Education," American Association for the Advancement of Science, *Second Conference on Scientific Manpower*, p. 15.

[45] United States Congress, Senate; 79th Congress, 2nd Session, *Report on Science Legislation from the Subcommittee on War Mobilization to the Committee on Military Affairs*, Report No. 8, pp. 4–5. According to another estimate, World War II was responsible for a loss of approximately 10,000 doctorates in science. See Scates, Murdoch, and Yeomans, *The Production of Doctorates in the Sciences*, pp. 34–37.

Shortages of scientific ability are all the more pressing when we recognize that there is a greater and greater dependence in our world on these men and women of high ability. Industrialization has long impressed upon us the interdependence of economic life in our society. This is an age of specialization. We depend for our existence on a multitude of skills and techniques that are essential in providing us with our food, clothing, and shelter. In return, society depends on each of us for some particular specialized labor or service. But in addition to this economic interdependence which makes us all cogs in a machine, there is an intellectual dependence of the many upon the few for the valuable creative ideas that are the germs of future progress. Information collected by the Washington University School of Management shows that 2 per cent of our population produces about 85 per cent of our tools and processes.[46] Our military security and economic strength rest in the last analysis on a small segment of our working force.

Regardless of our own specializations we will find ourselves more and more dependent on those few individuals of rare ability working, for instance, in stellar spectroscopy or in cosmic radiation, or on those chemists producing new synthetic substances, or on those at the frontiers of the medical science of chemotherapy, or on those who are working to divert the power in atomic fission to peaceful and constructive uses. If this increasing reliance on a few superior individuals out of whose intellects are bursting the great discoveries and inventions of our age should depress us with our own insignificance, it should also impress us with the dignity of man.

These statistics on specialized manpower shortages reveal something else about our society. There is need for greater flexibility in the use of both men and machines. The question of more effective utilization of trained specialists is receiving some attention but apparently not as much as it deserves. Some of our shortages of scientific ability might be met through greater operational flexibility, by encouraging the employment of more women in part-time jobs, by increasing the ratio of technicians to engineers and research scientists, and by reducing the amount of test tube washing and paper shuffling engaged in by our top-flight brains. The tabulation opposite illustrates the wide range in the actual ratio of technicians to engineers among different industries at the present time.

Of course, variations in this ratio from one industry to another are partly the result of different research demands, the extent of mechanization, and the type of goods produced in differing industries. Within an individual industry

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[46] Klinge, "Working with Gifted Science Students in Secondary Schools," *Science Education*, vol. 38, April, 1954, p. 223.

Ratio of technicians to engineers by industry[a]

Industry	*Technicians per engineer*
Aircraft	0.83
Electrical machinery	1.21
Machinery	1.49
Metal fabricating	1.92
Automobiles	2.47
Shipbuilding	3.17

[a] Wolfbein in National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, p. 58. See also United States Department of Labor, Bureau of Labor Statistics, *Employment Outlook for Technicians*, Bulletin 1131.

there are also wide ranges in the ratio. Paul Cohen has reported that the number of support workers per research worker varies from 0.9 for companies employing less than 500 to 1.6 for those with 5,000 or more employees. Larger companies usually employ proportionally more assistants, draftsmen, and other supporting personnel than small ones can afford to.[47] In a recent survey made by the Bureau of Labor Statistics, it was found that over 100 firms in the industrial chemical field had 6,200 professional employees and only 2,900 laboratory assistants and draftsmen.[48] The proportion of assistants per scientist is less in universities than in industry. Vannevar Bush has pointed out the disparity between the ratio of one assistant for every five scientists and engineers in academic life and the ratio of one assistant for every two scientists and engineers in industry.[49] It was recently suggested that current practices be changed to provide 10 technicians for every engineer.[50]

In view of the specialized manpower shortage, the expansion of part-time industrial employment for women would appear to be particularly useful. Although there would be expense and organizational changes involved in their return to shop or laboratory, women scientists whose children are grown should be able to provide industry with greater operational flexibility, even if they worked on a part-time basis. Indeed, the shorter the work week gets, the easier it should be for a woman to stay in the labor force.[51]

Handing over to technicians and others more and more of the work previously done by the research scientist is perhaps the easiest way for individual companies to meet the manpower shortage. This, of course, involves modification of some research techniques and perhaps foreshadows more widespread adoption of European methods, which utilize more assistants and thus give greater freedom to the top-flight researcher. Another way to meet the shortage is to upgrade good technician employees by giving them in-service training programs. Part of the difficulty here seems to be that the role of the technician in the industrial complex has never been fully developed or understood. American industry, it has been pointed out, does not generally utilize the technician to the fullest possible extent. A notable exception is, of course, the aircraft industry, which has made notable progress in the use of technician support for the unusually large numbers of engineers it must employ, but older industries have yet to take full advantage of what the job of technician offers. As a short-term solution, operational flexibility through more extensive use of women and technicians should not be overlooked.

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[47] Cohen, "Investing in the Future," *Technology Review*, vol. LVI, no. 8 (June, 1954), p. 405.

[48] Wolfbein, in National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, p. 59.

[49] Bush, *Science, The Endless Frontier*, pp. 121–127.

[50] *Engineering Manpower Newsletter*, Jan. 1, 1953, p. 28. See also Hausrauth, "Programs for Fuller Utilization of Present Resources of Scientific Personnel," *Science*, vol. 107, April 9, 1948, p. 362.

[51] See United States Department of Labor, *Part-Time Jobs for Women*; Mueller, *Educating Women for a Changing World*.

Flexibility is all the more important if we continue our restrictive policies of immigration. In the past our industrial machine has benefited from a large and healthy transfusion of gifted foreigners. Many of the fundamental scientific discoveries on which our technical superiority in World War II was based were made by European scientists. As a former Congressional subcommittee reported:

> "It should be somewhat humiliating to us to realize that the revolutionary sulfa drugs had their beginning in German research laboratories; that atom splitting was discovered in Berlin; that the basic pioneer work that has led to radio and radar and the enormous American electronic industries was that of a German professor. Penicillin came from England; DDT from Germany and Switzerland."[52]

Germany is represented first among Nobel winners in science, England is second, and the United States runs a poor third. We gained greatly, particularly in the field of theoretical physics, as a result of the influx of European refugees in the early 1930's; moreover, as J. Douglas Brown has pointed out, we have much to gain in the future from scientists outside our own borders. "It would be both arrogant and dangerous for us in the United States at this time to assume smugly that we can depend upon our own creative resources," he has stated.[53] How many native-born Americans does it take to equal a Fermi, a Szilard, an Einstein? Our immigration laws may well be preventing others of similar caliber from now coming to these shores. A very productive source of scientific ability may now be closed to us and our future shortage in this area will probably be all the more acute as a result of our current immigration policies.

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[52] United States Congress, Senate: 79th Congress, 2nd Session, *Report on Science Legislation from the Subcommittee on War Mobilization to the Committee on Military Affairs,* Report No. 8, p. 4.

[53] Brown, "The Shortage of Creative Manpower." *Monthly Labor Review,* vol. 77, no. 5 (May, 1954), p. 510. See also Price, *Government and Science,* p. 32; Simon, *The Neglect of Science,* p. 38; Cohen, *American Thought,* p. 71; Blizard, "The Future of Discovery and Invention," *Technology Review,* vol. LVI, no. 8 (June, 1954), p. 398.

Attention has already been given to the problem of overproduction of scientists and engineers. Such a possibility must, of course, be faced and its consideration is one of the more serious tasks of the supply and demand forecaster. From the estimates available at this time, however, it seems safe to assert that the dangers involved in a shortage of trained persons far outweigh the deleterious effects of an oversupply. The dismal picture painted by some economists cannot be ignored but should not deter us from facing the equally convincing evidence of a continual shortage in certain specialized fields. If ours were a static economy or static world, perhaps we should be more concerned with what lies beyond the shortages of the next few decades. But the fourfold growth of the professions in the first half of this century and the more rapid expansion in scientific and engineering areas point to a mushrooming of our productivity. Indeed, allowing fully for the possible problems of unemployment and dislocation on the horizon two or three decades hence, there is still a certain senselessness in crying wolf about surpluses unlikely to materialize in the face of continued critical shortages. Can there ever really be such a thing as too many geniuses, too many scholars?

In a sense, there is a certain repugnant unreality about the whole manpower concept. There is a dangerous tendency to translate researchers and engineers into so many heads of cabbage and to assume blithely that the same laws of supply and demand regulate the production of brains as of butter. This is what Kenneth Boulding must have had in mind when he protested against the "delusive simplicity" and crudeness in the manpower abstraction "as if it were simply a matter of counting noses." This kind of approach, he declared, "leads inevitably to a solution in terms of a monolithic, military, communistic type of society in which allocation is made by threat of violence imposed by superior members of a hierarchy."[54] We must remember that in the economics of scientific ability we are dealing first and foremost with human beings.

There is another obvious difference between the approach that can be used in stepping up production of steel or wheat or currency in circulation and increasing the scientific and technical labor supply. Increasing the quantity does not necessarily improve the quality. That is why careful attention must be given to the education and nurture of the promising individuals who can be found as well as to their raw numbers. Furthermore, demand figures sometimes reflect a need for one or two topnotch intellectual leaders rather than several thousand undistinguished, run-of-the-mill researchers. Increasing the number of physicists, if they were poorly trained, improperly motivated, or lacked the necessarily high ethical and intellectual standards, would not satisfy our need for another Einstein.

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[54] Boulding, "An Economist's View of the Manpower Concept," in National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, pp. 25–26.

There is still another problem connected with forecasting the supply and demand of those with scientific ability. Abundant evidence has recently been presented on the hazards involved in predicting future supply and demand curves in economic activity, to say nothing of the perils connected with political prognostication through public opinion polls. Indeed, estimates of future activity based on projections of existing trends should not, strictly speaking, be considered predictions or forecasts. The authors of a recently released governmental estimate of future economic growth wisely observed that the very predictions made may precipitate policy decisions which in turn may alter some of the assumptions and factors on which those predictions were based.[55]

Furthermore, the hazards involved in working with demand estimates for scientists and engineers are even greater than those connected with forecasting future gross national product, business inventories, or governmental military expenditures. In dealing with abilities and specializations we can only measure that which is measurable; we can identify only those needs which we now think of as identifiable. Before the discovery and development of radar there was little information on our future need for radar technicians. Before World War I there was little realization that this country would ever have a shortage of language experts or of specialists in the Near and Far East. Our economy and our culture are constantly changing. Fundamental inventions are about to be made; important research is in progress which will produce all down the line new demands for trained persons in many fields of specialized endeavor. The face of America and the world is changing. Our future demands will change too.

We have many statistics today on our present supply of physicists, chemists, and engineers and hence we can with some certainty project our future demand for persons in these categories. But little is said about our future supply and demand of the key men who will be crucial for the next phase of our development because perhaps we do not yet know what turns our development will take. As an illustration, perhaps a decade or two from now our compelling shortage will be of persons who span the scientific and nonscientific areas, who hold man and machine together, who can function at a high level of technical development yet move with ease among the masses of men. Perhaps our future need will be for those who can hold the gigantic and complex structure of our industrial society together, men who can comprehend, communicate, and control.

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[55] United States Joint Committee on the Economic Report, *Potential Economic Growth of the United States During the Next Decade*, pp. 1-2.

These and other conclusions raise serious questions for our democracy. Any efforts taken by the government, industry, professional associations, or individuals to increase our supply of engineers must be in keeping with our basic freedoms and democratic institutions. This is an elementary point but bears repeating at a time when freedom and the democratic way of life are attacked from so many directions. Even a shortage of atomic physicists does not justify denying to the individual his right to work when and how he pleases. The great challenge to our society is to scrutinize the tables of supply and demand, take whatever means are at hand to meet our current shortages in scientific ability, stay ahead in the race to produce more goods and services, more arms, more engineers, and more power, and at the same time preserve and strengthen the freedoms symbolized in the Bill of Rights. And the greatest challenge facing our time is perhaps to realize that man does not live by technology alone.

The mass of recently published information about our intellectual resources and our need for more talent should suggest that we have reached a new plateau in our economic development. M. H. Trytten speaks for a number of modern writers on human intellectual resources when he observes:

> "The concept of human resources as a supply so limited that the same careful thinking must be given to its proper utilization is almost absent from the literature prior to the second World War. The experiences of that war for the first time focused attention on the fact that in a global setting our manpower supply is not large, our problems are many, and the supply of personnel with advanced training can be and frequently is in many areas far short of the number needed to meet critical situations which can readily arise."[56]

The realization is dawning on us that we need a new concept of scarcity in our society. Economists in the past have used this concept to great advantage. Just as Western civilization in its early development experienced a lack of stability which led to the development of a feudal manorial system that would afford some measure of defense and protection; just as at one time there was a great shortage of food, clothing, and shelter that influenced the framing of a set of economic rules resting on a concept of scarcity; just as with the rise of capitalism a new shortage of money and credit techniques focused men's attention in this direction; just as the industrial revolution underscored a new shortage of power and our expanding industrial capitalism created a scarcity of natural resources; as with all these, so too our atomic era has its special kind of scarcity—a shortage of trained ability. Now that we have temporarily solved many of the material shortages that plagued us in the past, our generation must attempt to meet the shortage of trained ability with which we are now beset. In time other shortages, a lack of moral ability perhaps, may supercede our current crisis, but for the immediate future we need a politics and an economics, not to mention a philosophy, that deal with our shortage of developed specialized talent.

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[56] Trytten in Wolfle, *et al., Human Resources; The Needs and the Supply*, p. 53.

One point at which much of our potential specialized talent is currently lost is at the gap between secondary school and college. How much of the nation's high-level ability is being siphoned away from higher education and advanced training? To what extent is there need for a conservation program to salvage more capable boys and girls for specialized careers? It is to that subject we now turn.

The loss of talent from high school to college

We have seen that there is an increasing demand for trained persons in scientific and other professional fields and that there are currently acute shortages in engineering, science, teaching, and other professions. When college doors reopen next September many thousands of young persons with the ability to do the first-rate academic work required for entry into specialized fields will not be in college. This group of high school graduates will represent half of the top fifth in ability throughout the nation who for one reason or another will fail to enter college. In this group will be some who never intended to study beyond the high school level. But there will also be others among these non-college-going youngsters whose dreams will never be realized and whose contributions to society will never be as great as their potential talents and aspirations warrant. The failure of some of our best high school students to go on to college constitutes one of the more serious ways in which the nation wastes its intellectual resources.

An automobile worker's son in Detroit will discover that his family hasn't enough money for him to go to the college that has admitted him. A brilliant Negro youth in Georgia who is advised not to take the college preparatory course will never bother to apply to college. The death of her father will prevent a Kansas farm girl with an interest in mathematics from going on with her education. A 17-year-old in the top tenth of his class in Arkansas will never develop his budding interest in science because his school teaches no mathematics. A bright boy born on the wrong side of the tracks in New Jersey will be forced to go to work for his father the day after high school commencement. All over the nation, boys and girls who have the brains and ability that are its most valuable resource will interrupt their education prematurely and all of society as well as the youngsters themselves will be the losers.

What distinguishes students of high ability who succeed in getting a college education from those who don't? How many of our youth not now going to college should be persuaded to do so? How many of them would need financial assistance? How many young people are lost to the professions because of family or nonfinancial deterrents? What states have the highest college-going percentages and why? What improvement, if any, in current conditions can be expected as a result of the future flood of high school students? The following pages will attempt to provide partial answers to these questions.

Fortunately, there is a growing literature on the subject of college-going. Ever since Terman began his monumental study of outstanding children, many local surveys have been made to discover the proportion of high ability youth going on to college. In 1952 Byron S. Hollinshead's *Who Should Go To College* raised many provocative questions about higher education in general and the loss of capable youngsters at the college level in particular. More recently, Ralph Berdie's *After High School, What?* presented valuable figures on the extent of interest in attending college among high school seniors in Minnesota. The most useful book on this subject, however, is Dael Wolfle's *America's Resources of Specialized Talent*. His chapter on "The Potential Supply" is devoted to estimates of college-going at different levels of ability.

What does all this evidence indicate? First, it seems apparent that too many of our high ability youth are not now attending institutions of higher education despite the fact that the student's chances of going to college increase with his ability. In his nation-wide estimates, Wolfle declares that less than 42 per cent of the high school graduates who could score around 120 on the Army General Classification Test—the median score for college graduates—now go on to college. His college-going estimate for high school graduates who could score around 125 is 45 per cent; for those in the neighborhood of 135, 51 per cent; for those at the 140 or top 2 per cent in ability level, 54.5 per cent; and for those around the 150 score, almost 61 per cent. Even among the nation's geniuses, who would make a score of 163 or higher, Wolfle estimates that only seven out of 10 go on to college.[1]

In general, these figures agree with the estimates that Hollinshead made several years ago. Among the nation's high school students who were in the top quarter in ability, he concluded, over 40 per cent went to college, almost 40 per cent graduated from high school but failed to go to college, and about 20 per cent did not finish high school. He noted further that, for the nation at large, between 40 and 45 per cent of the boys and girls with IQ's of 115 or higher—a score that places them in the top 18 per cent of their age group in ability—went on to college.[2] Elmo Roper similarly reported that, in 1947, 46 per cent of the top two-fifths of a sample of high school seniors entered college.[3] Some idea of the extent of college-going among the nation's students of lesser ability is suggested in the more recent finding that approximately the same percentage—some 45 per cent—of all high school graduates in 1953 enrolled in college.[4]

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[1] Wolfle, *America's Recources of Specialized Talent*, p. 312. See also the tables on p. 176, 179, 183, and 314.

[2] Hollinshead, *Who Should Go To College*, p. 38, 121, 161.

These nation-wide figures on college-going are not by any means uniform throughout the country. Wide variations are found in the percentages of the 48 states and even for regions within states. One of the highest state percentages of college-going was reported by Phearman for Iowa. He discovered that among the state's superior high school graduates, 58 per cent of the top quarter, about two-thirds of the top tenth, and 92 per cent of the top 2 per cent all went on to college.[5] Part of the reason for this high percentage is that, in this state, a special effort has been made to discover students of unusual ability and to encourage them to further their education. Schoolchildren are given the Iowa Test of Educational Development periodically and the parents of those showing intellectual promise are informed of their children's abilities. Other states of comparable wealth could probably improve their figures by similar educational efforts. Through a similar program in Arkansas, for instance, an unusually high proportion—54 per cent—of those in the top quarter of their high school graduating classes went on to college in 1949.[6]

In his study of young geniuses in California, Terman found that about 88 per cent of both boys and girls ranking in the top 1 or 2 per cent of the population in intelligence entered college; the figure was 90 per cent for only the boys in his group.[7] California's performance in sending its youth to college, however, is unusually high. It ranked fourth among the states in the percentage of college-age youth attending institutions of higher learning in 1950. In the majority of states it can be expected that only between 50 and 60 per cent of the students in the top 1 or 2 per cent in intelligence continue beyond high school.

Several studies of college-going have been made in Minnesota. In 1938 Anderson and Berning reported that about half of the students in the top tenth in ability and about one-third of those in the top 30 per cent went to college. By 1945, Keller found, the corresponding figures were 52 and 41 per cent respectively. In reporting on his recent Minnesota study Ralph Berdie asserted that only two-thirds of the exceptionally well-qualified high school seniors in the state were planning to continue their education. In his follow-up survey one year after the study's original questionnaire had been answered, he found that three-quarters of those who planned to go had actually gone to college.[8]

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[3] Roper, *Factors Affecting the Admission of High School Seniors to College.*, p. 5.

[4] Ellson, *A Study of the Reasons Given by Superior High School Students for Their Decision to Enter or Not to Enter College*, p. 1.

[5] Phearman, "Comparisons of High-School Graduates Who Go to College With Those Who Do Not," *Journal of Educational Psychology*, vol. XL, November, 1949, pp. 405–414.

[6] Morehead, "What's Happening to Our High School Seniors?" *Journal of Arkansas Education*, vol. XXIII, no. 8 (April, 1950), p. 12.

[7] Terman and Oden, *The Gifted Child Grows Up*, p. 148, 167.

Studies in particular areas also yield illuminating information on college-going. A survey some years ago of over 1,000 high school graduates in Milwaukee with IQ's of 117 or above indicated that 41 per cent were in college on a full-time basis.[9] Another study revealed that 52 per cent of a group of Minneapolis public high school graduates who ranked in the top tenth of their class in college aptitude (and were thus of higher caliber than the 1,000 Milwaukee students) went on to college.[10] A much lower figure was reported by Barber in 1948 for Erie, Pennsylvania; he found that 30 per cent of those with IQ's of 115 or higher went to college.[11] Much more encouraging, however, is the figure Cowen reported for a 1953 sample of high school seniors in the Long Island, Albany, and Niagara Frontier areas of New York State: 77 per cent of those in the top tenth of their class were going to college.[12]

Studies that have been made of the variations in college-going within individual states have shown that throughout the nation the proportion of college students coming from urban areas is larger than the proportion from rural areas. To illustrate, it was found that almost half of the 1950 high school graduates in the New York City area planned to go to college, while only a little over one-third of those from upstate New York were college-bound.[13] Another New York State study, made in 1953, revealed that 55 per cent of the high school seniors in the heavily urban population of Long Island expected to attend college in contrast to a corresponding 42 per cent in the predominantly rural state capital district.[14] In Ohio, 30 per cent of the urban high school graduates in 1950 enrolled in college as against 21 per cent of those from rural regions.[15]

The rate of college-going varies not only by region and intellectual ability but also according to economic and occupational background of the students' families. The results of the National Study of High School Students and Their

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[8] Berdie, *After High School–What?* p. 14, 15, 58, 195.

[9] Goetsch, *Parental Contributions to Education, Income, and College Opportunity*, p. 30.

[10] Berdie, *op. cit.*, p. 14.

[11] Barber, "Why Some Able High School Graduates Do Not Go to College," *School Review*, vol. LIX, February, 1951, p. 93.

[12] Cowen, *Certain Factors Relative to the Continuance of Education of Graduates of Secondary Schools in New York State* (mimeo.), p. 22.

[13] Conger, *Lack of Funds and Lack of Motivation as Barriers to College Attendance in New York State*, p. 10.

[14] Cowen, *op. cit.*, p. 3, 7.

[15] White, *These Will Go to College*, pp. 68–70.

Plans, described in a following section, supplement earlier evidence showing that where a person is born and what his or her father does for a living determines to a great extent whether or not he or she goes to college. Indeed, the family's socio-economic status has been found to correlate closely with the number of years a child completes in school all along the educational ladder.[16]

In general, the higher the family's position on the economic scale, the greater the likelihood that the child will do well in school. The children of business executives and professional men perform better or respond more readily to classroom demands than do the children of manual workers. Apart from the factors involved in the inheritance of ability, boys and girls whose homes contain the accouterments of learning—books, magazines, records—reflect a higher level of achievement in their school subjects. William Gregg discovered that for New Haven, Connecticut, high school students the correlation between graduation and the rental value of the parents' homes was higher than for any other factor he studied.[17] In his 1947 survey Elmo Roper discovered that while 35 per cent of the children of professional men and business executives were in the top fifth of their classes, only 16 per cent of the sons and daughters of factory workers ranked in the top fifth.[18] A similar effect of family economic status on performance in school appeared in a study of New York State high school graduates entering college in 1940; of these students who were in the top quarter of their graduating classes, some 75 per cent came from families with incomes of 9,000 dollars or more a year, some 60 per cent from families with incomes between 5,000 and 9,000 dollars a year, and only some 40 per cent from families with incomes under 5,000 dollars a year.[19]

It is probably much less surprising that the family's economic status also has a great influence on whether or not the individual student wants to attend college. Two New York State studies provide specific examples of this; the first, conducted in 1950, revealed that 69 per cent of the state's high school seniors whose families had annual incomes of over 8,000 dollars planned to go to college, while only 27 per cent of those whose families earned up to 2,000 dollars annually had such intentions.[20] The second study, made in 1953 of high school graduates in the upper half of their classes, showed that these percentages of students in each family income range planned to go to college: 92 per cent, 8,000 dollars or more; 70 per cent, 6,000 to 8,000 dollars; 56 per cent, 4,000 to 6,000 dollars; and only 48 per cent, under 4,000 dollars.[21] Some idea of the extent of influence which ability and family income have on college-going can be seen in the following table, which is based on this 1953 study.

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[16] For a discussion of this point see Warner, Havighurst, and Loeb, *Who Shall Be Educated?* p. 61; Bell, *Youth Tell Their Story*, p. 93; Davie, "Social Class Factors and School Attendance," *The Harvard Educational Review*, vol. XXIII, no. 3 (summer, 1953), p. 184.

[17] Gregg, "Utilization of Census Data in Statistical Analysis of School Drop-out Problems," *The Journal of Experimental Education*, vol. XVIII, December, 1949, p. 148.

[18] Davis, *On Getting into College*, p. 16.

[19] Reeves, Henderson, and Cowen, New York State Legislative Document No. 31 (1948), *Matching Needs and Facilities in Higher Education*, p. 34.

[20] Congers, *op. cit.*, p. 12.

1953 New York State high school graduates who planned to attend institutions of higher education full time

	Estimated per cent by family income range		
IQ category	*$8,000 and over*	*$7,999–$4,000*	*under $4,000*
130 and over	96%	79%	72%
120–129	95	72	61
110–119	89	58	49

Regardless of family income, however, it is evident that a larger proportion of high school students from professional rather than from other occupational groups intend to go to college. In the National Study of High School Students and Their Plans, 67 per cent of the high ability seniors whose fathers were in professional occupations indicated they planned to go to college immediately after graduation. The corresponding figure for those whose fathers were in other white collar occupations was 55 per cent, for the farm group 38 per cent, and for the children of skilled and unskilled workers 27 per cent. In a different study, made of over 3,300 boys, it was found that almost nine out of 10 in the major white collar classes but only four out of 10 with fathers in the skilled labor and service categories expected to go to college. For children whose parents were unskilled laborers the corresponding figure was three out of 10.[22]

Considerable data have by now been amassed on the connection between father's occupation and college-going, both for particular areas and the entire nation. Local differences seem to represent only relatively slight variations on the national pattern. For instance, whereas almost 80 per cent of the children from the professional classes in Iowa go to college, apparently for the Milwaukee area covered by Helen B. Goetsch's study the figure was 90 per cent. For the sons of farm laborers included in Ellson's study, a slightly higher level of college-going was reported than for those in Phearman's group.[23] The most recent nation-wide figures are those in Wolfle's *America's Resources of Special-*

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[21] Cowen, *op. cit.*, p. 22.

[22] Kahl, "Educational and Occupational Aspirations of 'Common Man' Boys," *The Harvard Educational Review*, vol. XXIII, no. 3 (summer, 1953), p. 188.

[23] Phearman, *op. cit.*, p. 412; Ellson, *op. cit.*, p. 5; see also Warner, Havighurst, and Loeb, *op. cit.*, p. 54, 66.

ized Talent. Wolfle has estimated that two-thirds of the nation's high school graduates whose fathers are in professional and semiprofessional occupations enter college, as do about one-half of those whose fathers are in managerial and white collar occupations and only about one-quarter of those whose fathers are farmers or manual workers.[24] It is interesting to note in connection with the economic and occupational backgrounds of college-bound students that these factors influence not only college attendance itself but college choice. Raymond Mulligan has pointed out that students attending private liberal arts colleges come from families who stand higher on the economic and occupational ladder than the families of students who go to teachers colleges, junior colleges, or state universities.[25]

A great deal of information is also available on various noneconomic factors that influence college-going. Larger proportions of adolescents who want to go to college can apparently be found among Jewish and Protestant young people than among Catholic youth.[26] White children seem to have a greater interest in college-going than do Negroes. More of those who are relatively young at the time of high school commencement go on to college. Helen B. Goetsch, for instance, found that half the superior students she studied who were under 17 at the time of graduation went on to college, while the percentage declined for those of higher ages. Young people living in counties where there is a college or university stay in high school longer and seek higher education with twice the frequency of those residing in counties where there is no institution of higher learning.

Having considered some of the factors involved, let us examine the significant variations in college-going which exist among all the states and regions of the nation. There are, of course, several ways to compute current college-going "batting averages" by states. One must determine, for instance, what enrollment and what population figures produce the most meaningful college-going indices for our purposes. In addition, one must decide whether or not to include veterans in the enrollment figures.

In connection with veteran enrollments, Wolfle's *America's Resources of Specialized Talent* used only nonveteran residents 18 through 21 years old enrolled in college for 1949–50 to compute geographic differences in college attendance. One good reason for thus omitting veterans from a state-by-state inventory of college-going is that they may have been only a transitory student group which, constituting some 35 per cent of the nation's college enrollment in 1949–50, could have thrown long-range projections far off. However, there seem to be equally compelling reasons for including them. For one reason, military service and GI Bill educational privileges seem to have become regular features of our society. For another, the inclusion of veterans continues the long-range trend apparent in college enrollment figures from 1890 to 1940.[27] This last point suggests that substantial numbers of veterans would have decided to go to college even without the inducement of the GI Bill. Finally, most college-going studies of recent years have included veteran enrollments.

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[24] Wolfle, *op. cit.*, p. 160.

[25] Mulligan, "Socio-Economic Background and College Enrollment," *American Sociological Review*, vol. 16, no. 1 (April, 1951), p. 188.

[26] Berdie, *op. cit.*, p. 20.

In connection with college-going indices, some studies have ranked the states by the percentage of college entrants among all 18-year-olds in a particular year. Other studies have listed the states according to the number of college students per 10,000 population. This latter method seems especially unsatisfactory because the states exhibit wide differences in the school-age portions of their populations. South Carolina, for instance, has more than twice as many youngsters from the ages of five through 17 per thousand population than has California. In general, the largest proportions of children per thousand population are found in predominantly agricultural states and the smallest proportions in predominantly industrial areas.

Ronald B. Thompson's recent and noteworthy survey, *The Impending Tidal Wave of Students*, calculated state college-going percentages by dividing the number of those enrolled in colleges in the state by the state's college-age population. His figures are most helpful in judging the relative strengths and weaknesses of states as indicated by college student migration. Ostheimer's useful study, *Student Charges and Financing Higher Education*, used as a college-going index the percentage of those aged 15 through 24 in each state who were attending college anywhere in 1950.

Another slightly but significantly different way of expressing the differences among the states is by examining the percentage of young people aged 18 through 21 from each state enrolled as undergraduates in institutions of higher education anywhere in the nation. Table 5 lists the states in this manner for 1950. In that year college undergraduate enrollments represented approximately 26 per cent of the nation's college-age population. This figure has been increasing at the rate of almost 1 per cent a year, so that in 1955 about one-third of America's college-age youth attended institutions of higher education.

In examining this table, interesting regional variations are quickly apparent. The North Central and North Atlantic states have relatively high rates of college-going, while in the South Atlantic states the percentages are very low.

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[27] See Wolfle, *op. cit.*, p. 165. For a consideration of questions involved in including veterans in enrollment figures, see Scates, Murdoch, and Yeomans, *The Production of Doctorates in the Sciences: 1936–1948*, p. 58.

TABLE 5

COLLEGE-GOING *by states*, 1950[a]

Rank	*State*	*Percentage*[b]
1.	Utah	45.59
2.	New York	34.14
3.	Colorado	33.65
4.	California	32.83
5.	Kansas	32.28
6.	Idaho	32.23
7.	Oregon	32.02
8.	Connecticut	31.88
9.	Montana	31.50
10.	Massachusetts	31.38
11.	Ohio	30.52
12.	Washington	30.21
13.	Illinois	30.07
14.	Oklahoma	30.05
15.	Minnesota	29.57
16.	Nebraska	27.42
17.	Arizona	27.01
18.	Maryland	26.66
19.	New Jersey	26.57
20.	Iowa	26.51
21.	Missouri	26.32
22.	Wisconsin	25.78
23.	Nevada	25.56
24.	Michigan	25.50
25.	North Dakota	25.23
26.	Texas	24.71
27.	New Hampshire	24.06
28.	South Dakota	23.92
29.	Indiana	23.36
30.	Vermont	22.86
31.	Florida	22.81
32.	Pennsylvania	22.26
33.	Delaware	22.03
34.	Wyoming	21.27
35.	Louisiana	20.21
36.	West Virginia	20.15
37.	Arkansas	19.11
38.	Rhode Island	18.72
39.	New Mexico	18.22
40.	Georgia	17.38
41.	Maine	17.21
42.	Tennessee	17.20
43.	Alabama	17.04
44.	Kentucky	16.51
45.	Virginia	15.98
46.	Mississippi	15.19
47.	South Carolina	14.07
48.	North Carolina	13.90
	District of Columbia	61.35
	U.S.A.	25.79

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[a] Sources: Population data from United States Department of Commerce, Bureau of the Census, *U.S. Census of Population: 1950*, vol. II, part I, no. 1–48. Table 51; college data from Story, *Residence and Migration of College Students, 1949–50*, Table E.

[b] Percentage of college-age residents (18 through 21 years old) enrolled as undergraduates in any institution of higher education in the United States in 1950.

Twenty-one of the 48 states are above the nation-wide average of 25.79 per cent. Utah's college-going index of 45.59 per cent is the highest in the nation; indeed, in every recent study of college-going by states, Utah has led the list. New York comes next in the table with 34 per cent, followed by Colorado, California, Kansas, Idaho, and Oregon; Connecticut comes next and eighth with some 32 per cent. At the other end of the scale are the Carolinas with about 14 per cent each.

Can we find anything that would seem to account at least in part for these marked differences in college-going between states and regions? One hypothesis current in the educational world holds that the incidence of college-going varies according to certain characteristics of the high school, that the amount spent on teachers' salaries, the teacher-student ratio, and some other factors have a direct bearing on the number of the high school's graduates who continue their education. It might well be asked if some such correlation exists between college-going and certain characteristics of the state population and educational system. Suppose that we select the following six characteristics of the states for comparison with their college-going indices given in Table 5: income per capita, average expenditure per public school pupil, average annual public school salary, median expenditure level per classroom unit, median school years completed, and percentage of professional, technical, and kindred workers in each state's employed labor force.

When the 1950 statistics for each of these state characteristics are plotted against college-going "batting averages" for all 48 states, the resulting scatter diagrams seem to indicate more than an accidental connection between each characteristic and college-going. Such diagrams, illustrating in general that the state's college-going index increases or decreases with its income per capita, expenditure per pupil, and so on, appear in Figures 1 through 6. Figure 1, for example, illustrates the correlation between a state's per capita income and its college-going incidence. The relationship between them is apparently very close except for six states—Utah, Colorado, Kansas, Idaho, Montana, and Oklahoma—in which proportionately more high school graduates go to college than the per capita income would seem to suggest, and also except for six more states—Rhode Island, New Jersey, Pennsylvania, Delaware, Wyoming, and Nevada—where the rate of college-going is similarly lower than would be expected.

Detailed comparisons between individual states on the basis of the scatter diagram data are revealing. Although the population of Oregon is much smaller than that of Pennsylvania, Oregon's 1950 per capita income was almost as high as the Keystone State's. However, Oregon's 1950 educational expenditures were consistently higher than Pennsylvania's. Oregon's school salary figure was $3,368 as against Pennsylvania's $2,952; Oregon's average current expenditure per pupil was $280 compared with Pennsylvania's $215; and Oregon's median expenditure per classroom unit was $5,992 while Pennsylvania's was $4,626. Could these differences account in part for the additional 10 college-going students per hundred of college age found in Oregon? But the effect of low state educational expenditures can clearly be offset. Suppose that we compare the neighboring states of Utah, New Mexico, and Arizona, each of which had a college-age population of approximately 45,000 according to the 1950 census. In that year, although its per capita income was slightly higher than that of its two neighbors, Utah spent only $178 per pupil in contrast to New Mexico's $222 and Arizona's $240; Utah's median expenditure per classroom unit was $4,419, New Mexico's $4,543, and Arizona's $5,246. Yet their 1950 college-going rates per hundred were Utah, 45; New Mexico, 18; and Arizona, 27. Clearly, noneconomic factors must play a significant role in producing such contrasts. Perhaps Utah is an extreme illustration of the extent to which cultural and religious influences can affect college-going.

By and large, however, the proportion of college-age youth attending college increases with the state's expenditures for public education. The greater a state's effort on behalf of its children's educational needs, and also the greater its wealth and productivity, the more young persons it sends to institutions of higher learning. New York, Missouri, and Maine provide typical examples of this. New York in 1950 sent 34 per cent of its college-age youth to college; that year, its per capita income after federal taxes was $1,584, the median expenditure level per classroom unit was $7,627, the average current expenditure per pupil $295, and its annual school salary $4,200. In 1950 Missouri sent some 26 per cent of its college-age youth to college, a figure close to the nationwide 25.79 per cent; Missouri's per capita income in 1950 was $1,168, its median expenditure per classroom unit $3,553 and average per pupil expenditure $173, while its annual school salary was $2,576. In 1950 Maine sent 17.21 per cent of its college-age youth to college, the lowest state college-going figure outside the South; in that year Maine's per capita income was $1,036, the median level for classroom unit expenditures $2,662, the average amount spent per pupil $157, and its annual school salary $2,200.

It seems clear, therefore, that although there are other important factors which must not be overlooked, a combination of wealth, quantity of educational load, and quality of effort determines to a great extent a state's college-going percentage. If, for instance, all the states are listed according to rank in

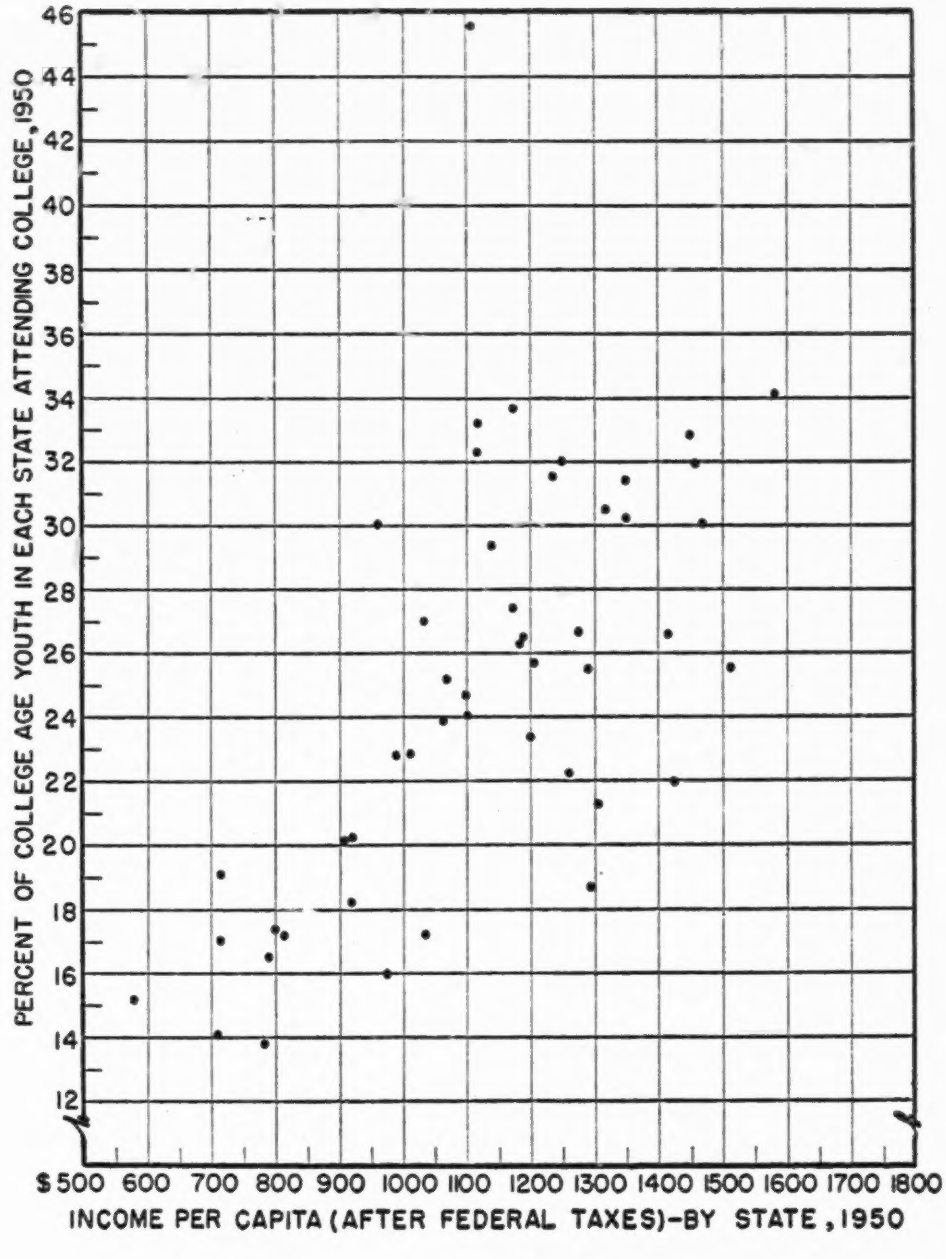

FIGURE 1. INCOME PER CAPITA *and college-going index for the 48 states*

terms of college-going and also in terms of their per capita income and of educational expenditures, and if comparisons between the separate lists are then made, it will be discovered that 36 states fall consistently in the same thirds —top, middle, and bottom—in all the lists. Six of the remaining states have higher college-going percentages than would be expected from their educational expenditures—the same six that were previously identified as having higher college-going percentages than would be expected from their per capita income. Six others of the remaining states have lower college-going indices than both incomes and educational expenditures suggest; they include four heavily populated industrial states—Michigan, Delaware, Rhode Island, and Pennsylvania—and the sparsely settled states of Nevada and Wyoming. With these exceptions, which cultural factors may well account for, the extent of college-going in a state seems to depend on the quality and quantity of public education available in the state and on the relative degree of effort its citizens are willing to expend on their schools.

The Educational Policies Commission has expressed a similar conclusion:

> "Analysis shows a fairly close correlation between the production of outstanding scientists by the several states and the educational expenditure per pupil. Data such as these suggest that adequate financial support for elementary and secondary schools tends to reduce the waste of talent. States and communities which 'save' by niggardly educational expenditures are in fact wasting their greatest potential resource—human ability, a resource which, when developed, could greatly increase wealth and well-being for all."[28]

If in some states a smaller proportion of the college-age population go to college than in other states, if there is a waste of talent, we should discover to what extent financial barriers account for the loss of students from high school to college. In attempting to estimate the potential number of college-age youth not now going to college who would be enabled to go by scholarship aid, it is necessary not only to recognize the many geographic, occupational, and cultural background variations in our adolescent population, but also to assess the extent to which a lack of financial resources is the determining factor in preventing a promising boy or girl from going to college. Many persons believe that anyone with ability can go to college and receive some sort of financial assistance if only he or she tries hard enough. Other people jump to the conclusion that able high school graduates do not go to college solely because they lack the money to go. But gradually the realization is dawning that the problem is not at all a simple one.

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[28] Educational Policies Commission, *Education of the Gifted*, p. 30. For additional statistics on state efforts on behalf of education see National Education Association, *Educational Differences Among the States.*

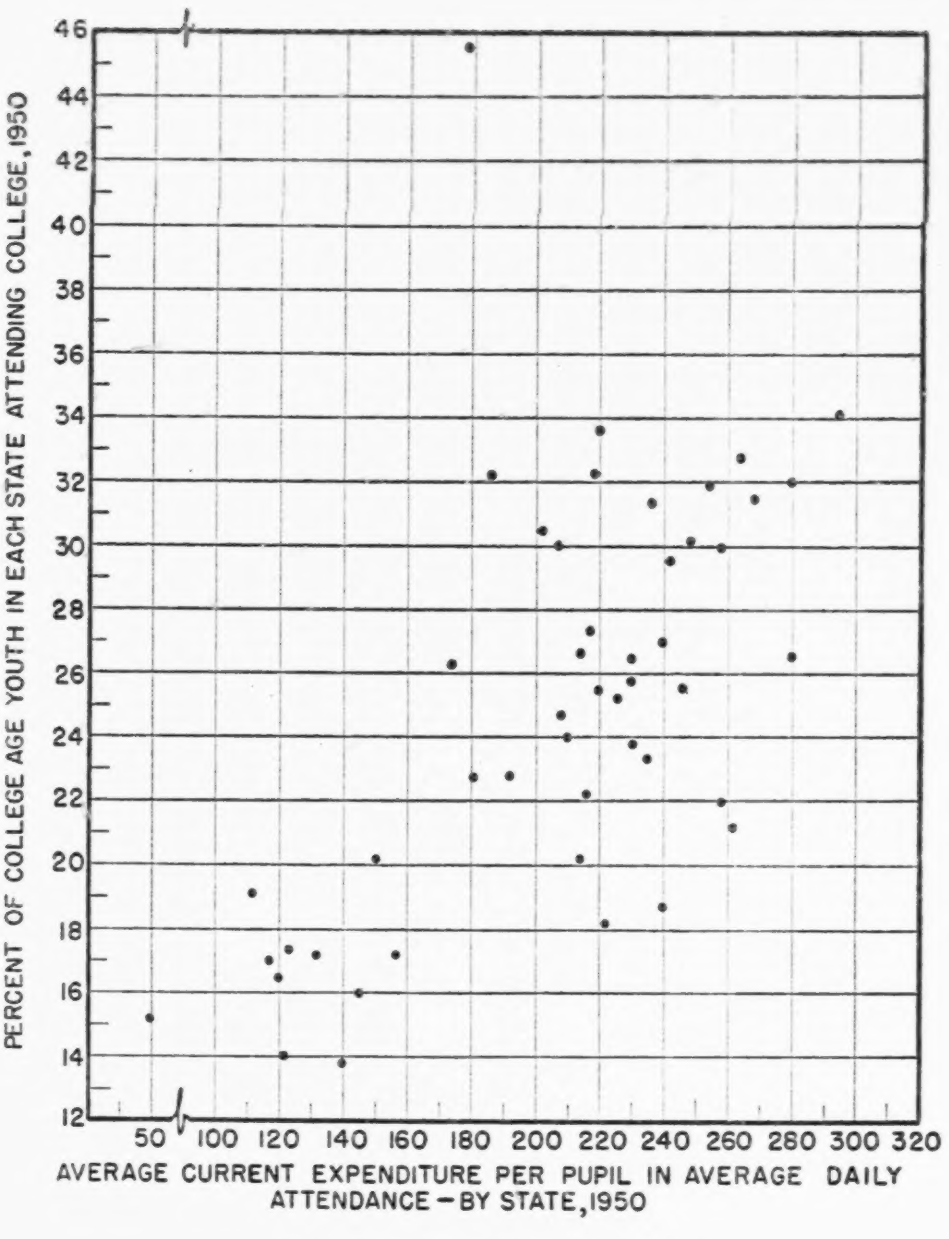

FIGURE 2. EXPENDITURE PER PUPIL *and college-going index for the 48 states*

Considerable evidence has been amassed on the extent to which lack of money prevents young people from continuing their education beyond high school. Most studies have agreed that before World War II, insufficient funds may have been the reason why two-thirds of those of high ability failed to go on to college. For example, in 1940 Helen B. Goetsch reported that 64 per cent of the able young people studied who were not in college were unable to go because of financial need.[29] Regional differences exist, of course. For example, it was found in the late 1940's that about one-third of Iowa's high ability youth who did not go to college failed to go because of financial need.[30] The corresponding percentage in Ohio was 40 and the comparable figure for Indiana high school graduates was 50 per cent.[31]

In a survey made some time ago, 35 per cent of the superior high school graduates in Erie, Pennsylvania, listed insufficient finances as their principal reason for not going to college.[32] A number of years ago it was reported that 59 per cent of the New York State high school graduates who were in the top quarter of ability and whose families had incomes of less than 5,000 dollars failed to go to college, most of them, presumably, because of financial need. Conducting a more recent New York study, Louis Conger discovered that about one-sixth of the state's public high school graduates who did not plan to go to college in 1950 attributed the fact to lack of funds. This group constituted 9.4 per cent of the state's total secondary school graduates that year.[33] Ralph Berdie's valuable study revealed that fully one-half of Minnesota's high ability youth who were not planning to attend college would have gone if they had had enough money. In the follow-up study of this group, made one year later, 36 per cent of those who were working indicated that they would still go to college were it not for insufficient financial resources.[34] In California, on the other hand, only about two-tenths of the high ability seniors and three-tenths of all seniors qualified for college were financially unable to go, according to a recent questionnaire survey of California high schools.[35]

A number of careful assessments have been made of the extent to which financial need limits college-going among able students throughout the entire nation. In the National Study of High School Students and Their Plans, about 12 per cent of the high-scoring seniors indicated that if they did not go to col-

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[29] Goetsch, *op. cit.*, pp. 33–34.

[30] Phearman, *op. cit.*, p. 409.

[31] Steelman, *Science and Public Policy*, vol. 4, p. 26, 145.

[32] Hollinshead, *op. cit.*, pp. 161–162.

[33] Conger, *op. cit.*, p. 45.

[34] Berdie, *op. cit.*, p. 17, 69, 218.

[35] Mitchell, "State Scholarships for Superior Students," *California Journal of Secondary Education*, vol. 25, Dec., 1950, p. 400.

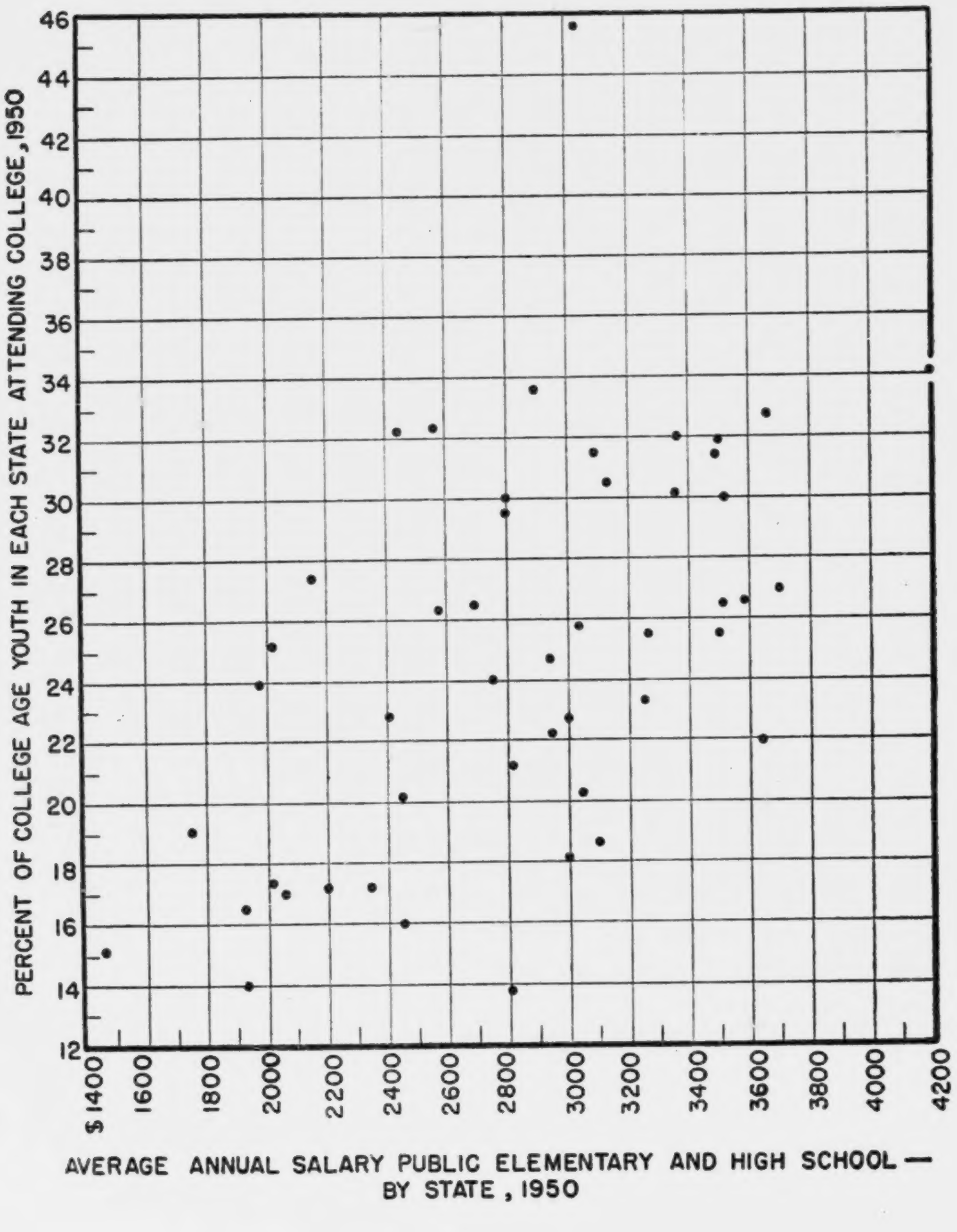

FIGURE 3. AVERAGE SCHOOL SALARY *and college-going index for the 48 states*

lege the expense involved would be the most important reason for their not going. Almost half of these seniors in the top 30 per cent in ability reported that finances would be an important factor in such a decision. A few years ago Hollinshead concluded that about one-third of the nation's superior youth who did not go to college were prevented from going by insufficient finances, while the other two-thirds lacked the interest or motivation to go.[36]

This agrees rather closely with a statement made by M. H. Trytten before a House of Representatives subcommittee in 1949. Dr. Trytten declared that approximately one-third of the nation's college-age students capable of doing postgraduate work lacked the initial opportunity to go to college and about one-fourth of the highly qualified college graduates who would like to go to graduate schools cannot do so for lack of funds.[37] During the 1950's the proportion of college-age youth unable to continue their education for financial reasons alone appears to be decreasing, partly because of continued prosperity. It is very difficult, however, to separate finances from the other factors which keep able students from attending college.

TABLE 6

MOTIVATION FOR COLLEGE *and educational levels completed for every 100 boys in the top quarter in ability*[a]*—Havighurst's estimates*

Motivation[b]	*Finish college*	*Drop out of college*	*Finish high school only*	*Drop out of high school*	*Total*
Well-motivated	35	5	14	0	54
Non-motivated	0	5	14	4	23
Mal-motivated	0	3	14	6	23
Total	35	13	42	10	100

[a] Top quarter criteria used, IQ scores of 110 or higher.
[b] Well-motivated—those who are strongly impelled toward college and a professional career; non-motivated—those who lack any desire for a higher education; mal-motivated—those who have personality or character traits which would hinder or prevent satisfactory work in college.

In a memorandum prepared for our study, Robert J. Havighurst has attempted to estimate how much of the nation's current loss of high ability boys might be salvaged by a scholarship program. His figures, given in Table 6, indicate that out of every hundred boys in the top quarter in general ability some 48 now enter college, 35 complete college, 42 finish high school but do not enter college, and 10 do not finish high school. Table 6 also shows the varying degrees of motivation for college found among each of the above groups. Table 7 similarly breaks each of these groups down by economic

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[36] Hollinshead, *op. cit.*, pp. 81, 157, 162–164.

[37] United States Congress, House of Representatives, 81st Congress, 1st Session, *Hearings before a Subcommittee of the Committee on Interstate and Foreign Commerce*, p. 100.

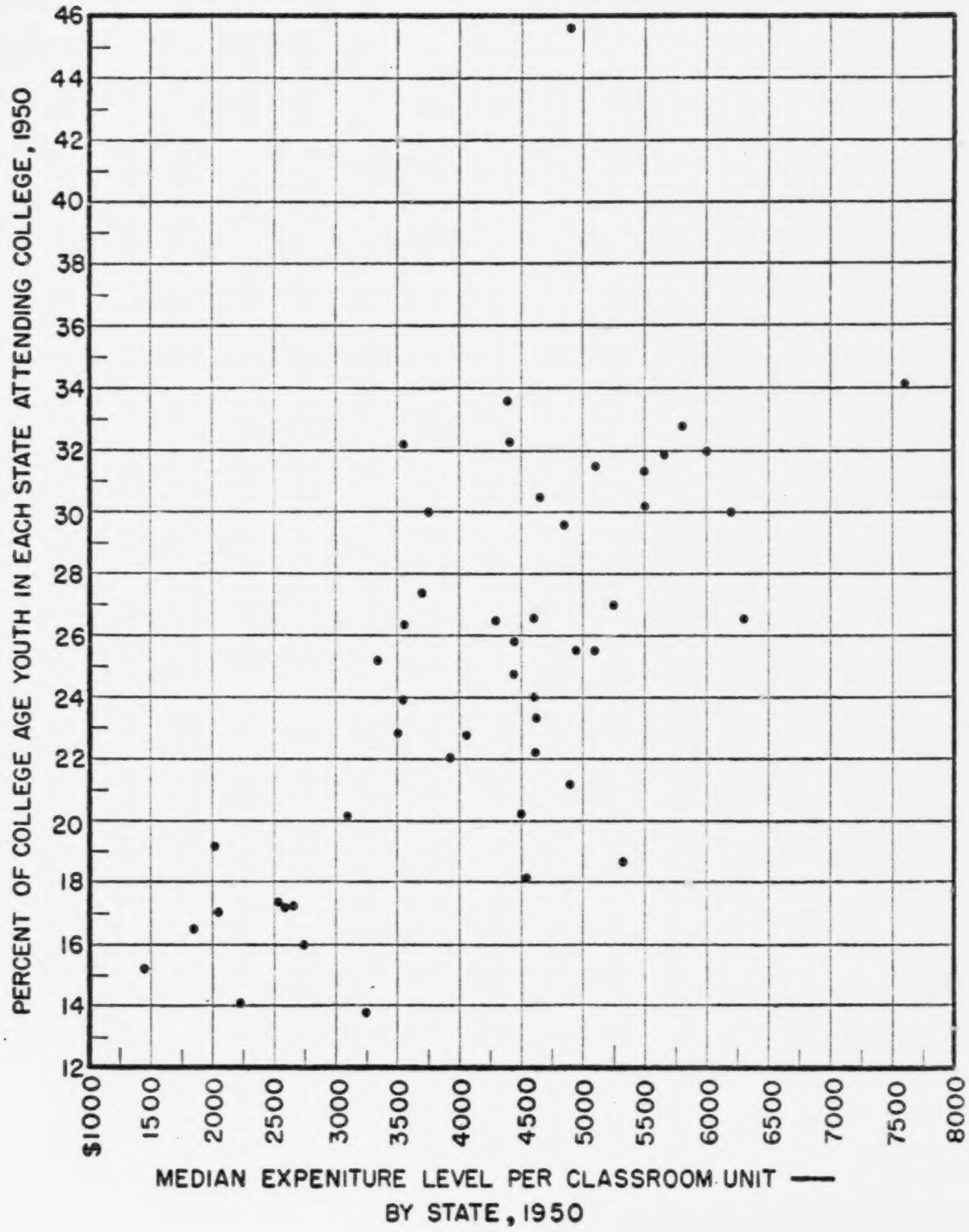

FIGURE 4. EXPENDITURE PER CLASSROOM UNIT *and college-going index for the 48 states*

status categories, and Table 8 gives an estimate of the degree of motivation by economic status among those boys in every hundred of high ability who in the one case presented do not enter college and in the other case do not finish college.

On the basis of his data, Havighurst has estimated that about 19 per cent of the boys in each one-year age group who are also in the top quarter in ability want to go to college but would need scholarship aid to complete the four

TABLE 7

ECONOMIC STATUS *and educational level completed for every 100 boys in the top quarter in ability*[a]*—Havighurst's estimates*

Economic status[b]	*Finish college*	*Drop out of college*	*Finish high school only*	*Drop out of high school*	*Total*
Upper	15	3	2	0	20
Middle	10	5	18	2	35
Lower	10	5	22	8	45
Total	35	13	42	10	100

[a] Top quarter criteria used, IQ scores of 110 or higher.

[b] Status defined by parental occupation: upper—professional, managerial; middle—minor white collar, clerical, highly skilled workers, farm; lower—semiskilled and unskilled workers.

TABLE 8

COLLEGE MOTIVATION AND ECONOMIC STATUS *for every 100 boys in the top quarter in ability who do not finish college*[a]*—Havighurst's estimates*

Economic status[b]	*Well-motivated*[c]	*Non-motivated*	*Mal-motivated*
BOYS WHO DROP OUT OF COLLEGE			
Upper	0	2	1
Middle	2	2	1
Lower	3	1	1
Total	5	5	3
BOYS WHO FINISH HIGH SCHOOL ONLY OR DROP OUT OF HIGH SCHOOL			
Upper	0	1	1
Middle	5	8	7
Lower	9	9	12
Total	14	18	20

[a] Top quarter criteria used, IQ scores of 110 or higher.

[b] Status defined by parental occupation: upper—professional, managerial; middle—minor white collar, clerical, highly skilled workers, farm; lower—semiskilled and unskilled workers.

[c] Well-motivated—those who are strongly impelled toward college and a professional career; non-motivated—those who lack any desire for a higher education; mal-motivated—those who have personality or character traits which would hinder or prevent satisfactory work in college.

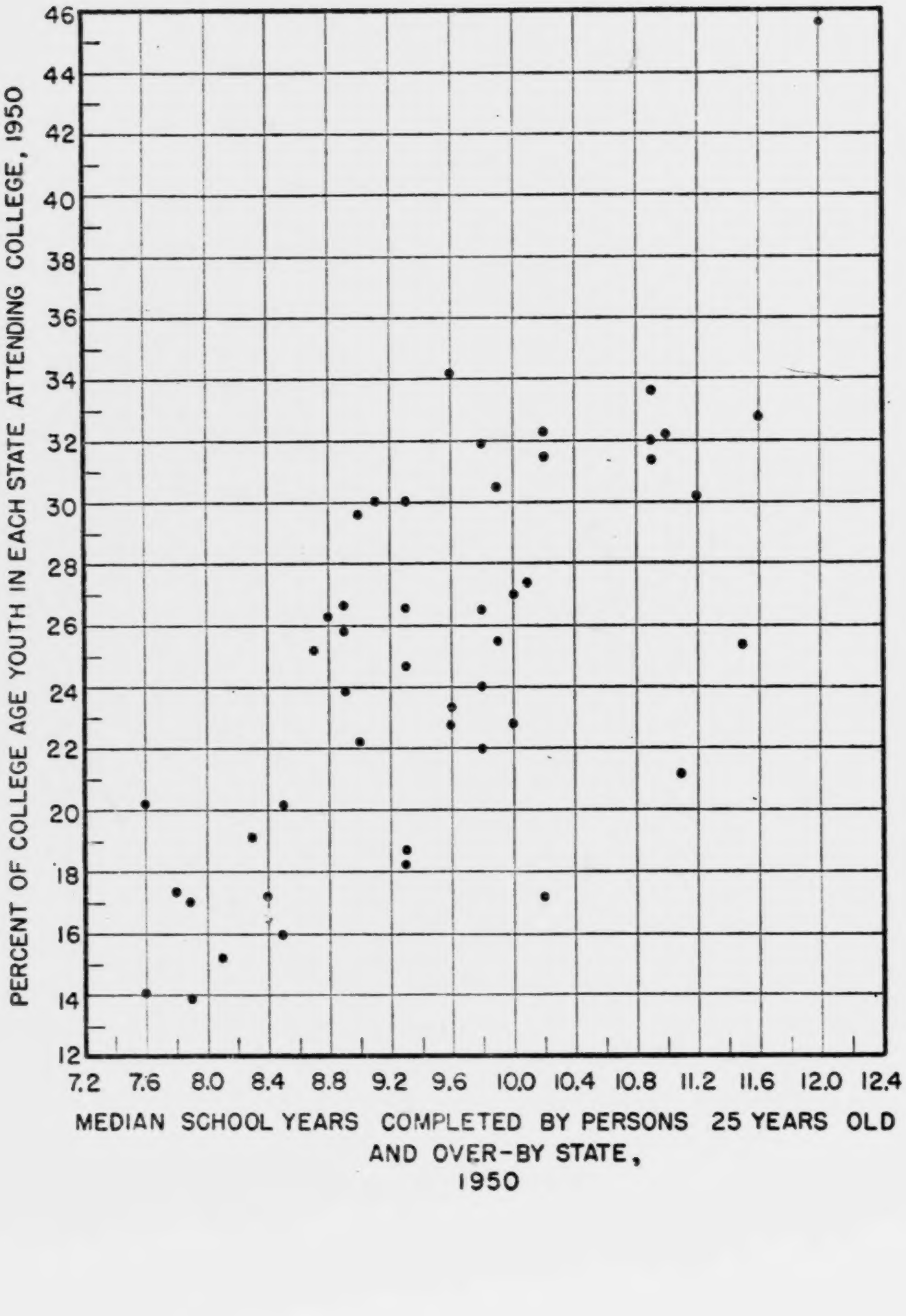

FIGURE 5. MEDIAN SCHOOL YEARS COMPLETED *and college-going index for the 48 states*

college years. This would currently amount to approximately 50,000 boys. Without financial aid one-quarter of these 50,000 would have to leave college before graduation, while the remaining three-quarters would never get to enter college.[38]

A similar estimate could be made for girls. Generally speaking there appear to be no sex differences in the distribution of ability; about the same number of girls as boys ought to be found in the top quarter of general intellectual ability. But the waste of talent among girls is greater than that among boys. A larger proportion of girls graduate from high school but a larger proportion of boys go to college. When families can send only one child to college, it is most often the boy who goes. In the National Study of High School Students and Their Plans twice as many girls as boys reported that they would really like to attend college but would not be able to do so. In contrast, almost twice as many able girls as boys indicated no interest in further education, corroborating the impression that lack of motivation for college is found more frequently among girls than among boys. In general, there would appear to be about the same number of each sex in need of financial support.

Our estimate of the annual number of high ability high school graduates in the nation not now going to college for financial reasons, but who presumably could be won to higher education by means of a scholarship program, is between 60,000 and 100,000.[39] Of course, more than that number of scholarships would be needed if all of these persons were to be helped since some able students who now can barely afford college but go anyway would rightfully receive scholarship assistance if more awards were available. Furthermore, these figures do not include the many thousands who manage to stay in college and graduate but whose limited resources prevent them from fully developing their abilities. It seems fair to assume, for instance, that some needy students who do finish college cannot pursue further professional or scientific studies because of the heavy investment of time and money these studies require. College scholarships would help such students by conserving some of their financial resources for graduate work. If the nation is interested in efficient utilization of its intellectual resources it would appear that at least 150,000 additional scholarships a year for superior boys and girls are needed immediately.

Although the problem of financial need among college students and graduates is not quite so urgent as the problem of need among able high school

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[38] See Havighurst, "The Individual: Personal Problems in Approaching Equality of Opportunity," in American Council on Education, *Approaching Equality of Opportunity in Higher Education*, pp. 67–81.

[39] For additional estimates based on the National Study of High School Students and Their Plans see p. 140.

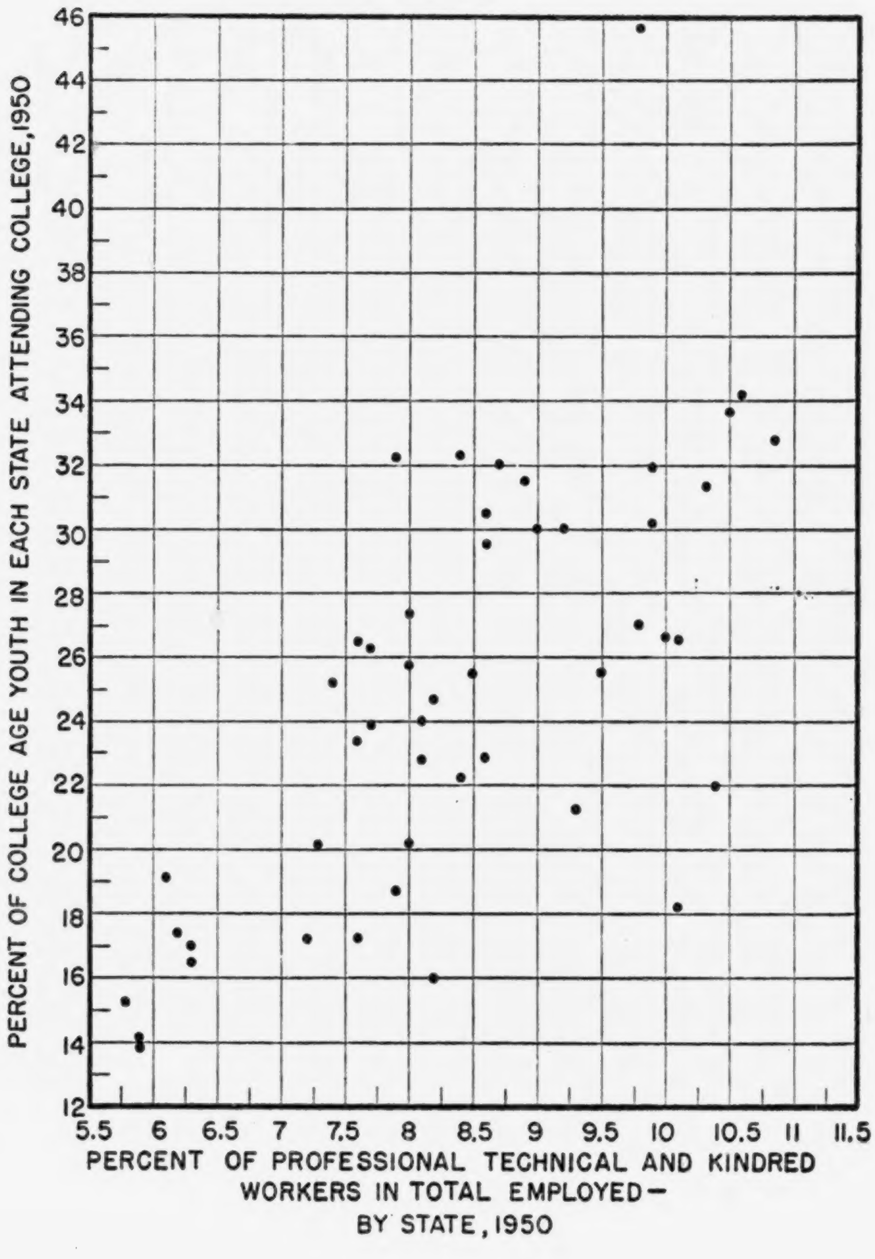

FIGURE 6. PROFESSIONAL AND TECHNICAL WORKERS *and college-going index for the 48 states*

graduates, it has an important bearing upon specialized manpower shortages. Half of the students who start college do not graduate. A lack of funds frequently forces a student to interrupt his college education or to drop out altogether. Many young people do not do as well as they should in college because they are obliged to carry heavy part-time jobs. In Iowa, Phearman found that only half of the students in college had all their expenses paid by their families. Less than one-third of the men students were in this category, while 22 per cent—almost one-fourth of the college men—were forced to pay all their own way.[40] Although his estimate may have been high, McGrath declared some years ago that "low parental income is . . . the principal reason why seven out of 10 persons who have college abilities never finish an undergraduate course of studies."[41]

Further statistics on the attrition at the college level indicate how seriously it cuts into the nation's resources of talent. Dael Wolfle has estimated that, among the nation's college students who could score around 120 on the Army General Classification Test, only some two-thirds of those who enter college graduate; among college entrants who could score 130, four-fifths graduate; and among those who could score 140, nine-tenths graduate. Only half of all those students in the nation-wide top quarter in ability who enter college stay on to graduate; three out of every ten in the nation's top tenth in ability and one out of every ten in the nation's top 2 per cent in ability who go to college fail to graduate.[42] C. Gilbert Wrenn earlier reported an even lower figure for a group of Minnesota high school graduates; in 1947, nine years after their high school graduation, only 45 per cent of those who had been in the top 16 per cent of their class had bachelor's degrees.[43] Even though the percentage of college students who graduate is increasing at the rate of 0.3 per cent a year we are still wasting talent on an extravagant scale. Taking into account both the attrition in college and the loss of those who never start college, it may be estimated that only two-thirds of the nation's high school graduates who are in the top 2 per cent on the basis of intelligence and high school grades graduate from college, and only about 40 per cent of the high school graduates in the top quarter are in this happy category.

At the graduate level the loss to the nation of capable talent is even greater.

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[40] Phearman, *op. cit.*, pp. 410–411.

[41] McGrath, "On the Outside-Looking In," *School Life*, vol. XXXII, January, 1950, p. 57.

[42] Wolfle, *op. cit.*, p. 312.

[43] Wrenn, "Potential Research Talent in the Sciences Based on Intelligence Quotients of Ph.D.s," *The Educational Record*, vol. 30, No. 1 (January, 1949), pp. 20–22. See also National Manpower Council, *op. cit.*, p. 83; Hollinshead, *op. cit.*, p. 15, 121; Millett, *op. cit.*, p. 49; Committee on Manpower Resources for National Security, *Manpower Resources for National Security*, part IV, p. 36; Ellson, *op. cit.*, p. 1.

In 1953, 8,309 doctoral degrees were conferred by American universities.[44] In 1955, the figure was 8,840. In the decade of the 1940's, an average of 3,300 a year were conferred. At the present time, only one-fifth of the men who graduate from college and who have the ability to do doctoral work acquire the Ph.D. or M.D. degrees.[45] Of all those in the nation capable of making an Army General Classification Test score of 130 or higher, only one man in 30 receives a Ph.D. Among women of equal ability the ratio is one in 300.[46] While not all such gifted people should do graduate work, it is obvious that a considerable waste of human resources takes place at this level.

To return to the question of financial need among the nation's able and well-motivated high school graduates, we have estimated that there are approximately 100,000 such graduates each year who would need financial aid to enter college. However, it would be far more difficult to ascertain the numbers of high school students in each state or region of the nation who might be enabled by financial aid to get a college education. For one thing, the proportion of young people of college age varies considerably from state to state, as we have seen. For another, variations in educational effort and other conditions among the 48 states result in variations in the "holding power" of the high schools. Three indices of this holding power are presented for each state in Table 9, which lists the states alphabetically and gives the percentages of each state's youth 14 through 16 enrolled in school in 1950, the percentages of their public secondary school pupils enrolled in the ninth grade in 1947 who graduated four years later, and the percentages of their 18-year-olds who were public high school graduates in 1949–50. It will be noted that while about half of all the nation's 18-year-olds that year were graduates of public secondary schools, the state percentages ranged from Louisiana's 29 to Idaho's 73.

Furthermore, there probably are also wide geographical variations in the incidence of high ability in the population. We have a rough gauge of the distribution of college-level ability by states in the scores made on the Selective Service College Qualification Test. This test was drawn up to provide data which local Selective Service Boards might use in deciding whether or not to postpone the induction of individual students. When the results of the first such tests—given in 1951—were tabulated, the percentages of college students in each state who scored 70 or higher varied from 79 per cent in New Hampshire to 31 per cent in Mississippi. (This score of 70 was comparable to a score

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[44] United States Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1954*, p. 139.

[45] National Manpower Council, *op. cit.*, p. 18, 90; Bowles, "The Future Supply of Scientists," *The Educational Record*, vol. 35, No. 2 (April, 1954), p. 111.

[46] Wolfle, *op. cit.*, p. 184.

TABLE 9

HOLDING POWER *of public high schools by states*[a]

State	*Per cent aged 14–17 in school*[b]	*Per cent graduating of those starting*[c]	*Per cent graduates among 18-year-olds*[d]
Alabama	78.0%	56.2%	36.4%
Arizona	79.4	59.4	41.9
Arkansas	77.5	60.1	44.5
California	90.5	68.1	55.9
Colorado	84.2	67.5	50.8
Connecticut	88.1	70.5	52.5
Delaware	81.8	64.9	47.0
Florida	82.7	63.9	43.6
Georgia	73.4	34.5	32.4
Idaho	88.5	69.2	73.2
Illinois	87.1	68.9	51.3
Indiana	86.3	64.9	57.8
Iowa	87.5	75.6	64.7
Kansas	86.3	74.0	65.6
Kentucky	69.9	56.2	33.4
Louisiana	79.1	56.7	29.1
Maine	82.8	65.6	46.4
Maryland	79.9	59.2	25.9[e]
Massachusetts	86.6	70.5	50.8
Michigan	88.5	71.6	53.2
Minnesota	87.2	74.9	62.7
Mississippi	77.9	54.2	34.8
Missouri	80.1	62.8	45.3
Montana	87.7	70.4	63.1
Nebraska	85.9	72.4	66.1
Nevada	89.2	63.0	61.1
New Hampshire	85.6	76.8	47.6
New Jersey	86.3	64.1	53.4
New Mexico	80.8	53.6	36.8
New York	87.6	53.4	52.0
North Carolina	78.1	56.2	40.2
North Dakota	81.6	71.0	54.1
Ohio	88.6	67.2	56.8
Oklahoma	86.6	64.8	56.8
Oregon	91.4	65.9	63.5
Pennsylvania	86.9	62.6	57.2
Rhode Island	81.4	56.5	37.1
South Carolina	72.0	55.3	30.1
South Dakota	82.9	75.0	59.8
Tennessee	77.4	53.2	35.4
Texas	78.0	60.3	40.6
Utah	92.8	72.4	57.3
Vermont	83.9	69.3	41.2
Virginia	77.6	51.0	36.0
Washington	89.7	64.7	55.7
West Virginia	78.7	57.3	49.8
Wisconsin	89.8	80.3	63.9
Wyoming	85.4	69.7	54.2
Dist. of Columbia	85.0	50.5	36.2
Continental U.S.	83.7	62.5	48.7

[a] Sources: first two columns, Gaumnitz, *High School Retention by States*, United States Department of Health, Education, and Welfare, Office of Education, Circular No. 398; third column, census data and United States Office of Education figures.

[b] Percentage of those from the ages of 14 through 17 who were enrolled in public and private schools in 1950.

[c] Percentage of public high school pupils graduating in 1950–51 among those who had been enrolled in the ninth grade in 1947–48.

[d] Percentage of public high school graduates only among all 18-year-olds in 1949–50.

[e] Maryland's percentage of 18-year-olds who were public high school graduates was low in 1949–50 because in that year many of the state's school systems were in transition from 11 grades to 12 grades.

of 120 on the old Army General Classification Test.) Table 10 lists the percentages of students scoring 70 or higher for each state. There is little basis, however, for assuming that the distribution of high ability among a state's high school graduates is similar to the distribution of high ability among the college undergraduates in a state.

This uneven geographical distribution of ability was reflected more recently in the scores earned by high school seniors on the college aptitude test given in connection with the National Study of High School Students and Their Plans. The regional percentages of those scoring in the nation-wide top 30 per cent were as follows: in the West, 35 per cent; in the Northeast, 34 per cent; in the Central states, 29 per cent; and in the South, only 20 per cent. To complicate matters further, regional differences in financial need and in motivation for college appeared in the tabulation of responses to the National Study questionnaire.[47]

In view of all these variations, therefore, the able high school graduates who will be prevented from continuing their education by insufficient finances are probably not distributed evenly throughout the population. There may be as few as 200 in states like Vermont and as many as 10,000 in states like Pennsylvania. They constitute an elusive group and an extensive "talent search" would be needed to find all or even most of them.

However, this is a group that merits our immediate attention. This widely scattered, divergent segment of the nation's 18-year-olds characterized by high ability, an interest in achieving greatly, and inadequate financial resources constitutes a pool from which could be drawn many of the engineers, teachers, scientists, and other leaders we need so desperately today. Some of these students may easily be found, for they are the college applicants who though admitted fail to enter college at the last minute because of insufficient funds. They are also the mechanics' sons and shopkeepers' daughters with a reputation for being bright who might have gone to college had there not been a sudden change in the family's fortunes. They are the new apprentices on the job who find a summer's paycheck impressive enough to make college seem an overly expensive interruption in their lives.

But others will be more difficult to find, for they are not to be observed above the sea of unfamiliar faces. They are the silent sufferers of a way of life that passes them by. Among these would be the intelligent Negro destined to remain a Pullman porter because it was just expected he would go to work right after high school, the quick-witted rancher's son in Montana whose sec-

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[47] See p. 223.

TABLE 10

COLLEGE-LEVEL ABILITY *by states as indicated by score on the Selective Service College Qualification Test*[a]

State	*Registrants scoring 70 or above*
Alabama	39%
Arizona	62
Arkansas	38
California	65
Colorado	63
Connecticut	76
Delaware	66
Florida	53
Georgia	42
Idaho	56
Illinois	65
Indiana	66
Iowa	66
Kansas	61
Kentucky	42
Louisiana	43
Maine	66
Maryland	62
Massachusetts	76
Michigan	69
Minnesota	73
Mississippi	31
Missouri	60
Montana	60
Nebraska	61
Nevada	62
New Hampshire	79
New Mexico	53
New Jersey	70
New York	72
North Carolina	46
North Dakota	59
Ohio	65
Oklahoma	48
Oregon	64
Pennsylvania	66
Rhode Island	59
South Carolina	33
South Dakota	59
Tennessee	48
Texas	46
Utah	56
Vermont	59
Virginia	50
Washington	66
West Virginia	41
Wisconsin	69
Wyoming	63
Dist. of Columbia	70
Continental U.S.	64

[a] Percentage of registrants for the tests who scored 70 or above listed only for the College Qualification Test given from May through July 1951. Source: Educational Testing Service, *A Summary of Statistics on the Selective Service College Qualification Test of May 26, 1951; June 16, 1951; June 30, 1951; July 12, 1951*, p. 38.

ondary school never got around to discovering his high IQ, the Puerto Rican girl living on the outskirts of Harlem who wants desperately to go to college but is resigned to serving sandwiches in a third-rate luncheonette. Among them are the victims of the wasteful, forgetful, and sometimes stupid and intolerant discriminations still existing in our land.

If these deserving youths could be discovered and supported in their quest for higher education, the gain to our society each year would be incalculable. In terms of productivity it might represent five new inventions comparable to the electric light or television, or a dozen important labor-saving devices. In terms of knowledge, understanding, perspective, and vision to cope with the complexities of the modern age, it would certainly mean a more enlightened, more effective segment in our population.

These figures on college-going suggest other conclusions. The most elementary ones—that talent is obviously being wasted, that the "raw material" for more scientists and engineers is close at hand throughout the nation, and that the biggest loss perhaps occurs at the transition point between high school and college—have already been stated. It has also been made clear that the lower the family's position on the economic and occupational scale the smaller will be the son's or daughter's chances of going to college. This means that the upper economic strata of our society are already well represented in college while the lower economic classes are inadequately represented. It may be expected that the present gradual rise in our standard of living will further democratize our college rolls, but this is far too slow and haphazard a process to depend on for conserving intelligence that we can no longer afford to waste.

It might also be concluded that, since parents in the professional and middle classes inculcate a love of learning and a desire for college in their children, the financial deterrent is no doubt relatively more important for them than motivation. On the other hand, among the families of skilled, semiskilled, and agricultural workers, as well as among certain minority groups, lack of motivation and other cultural factors probably outweigh financial considerations. Consequently, financial assistance to the children in these groups, to be effective, must be accompanied by programs to awaken and develop an interest in the things of the mind, a desire for higher education, and a willingness to sacrifice for the sake of intellectual accomplishment. It is also apparent from this, and from previously cited figures as well, that widespread lack of motivation for college is numerically more significant in keeping capable high school graduates from going to college than lack of funds. Nonetheless, the financial barrier is sufficiently important by itself to justify additional scholarship aid, particularly if that financial support were accompanied by a program to increase motivation for college.

More fundamental perhaps is the question of social responsibility involved in these statistics on wasted talent. Can we leave it to chance to shuffle the most able adolescents into college classrooms? To what extent should we be concerned whether or not all the right persons go to college? Does the talented individual have an obligation to develop his abilities to the fullest and does society have a corresponding obligation to enable him to do so? Nelson Henry must have had this in mind when he wrote:

> "Time was when persons, capable but uninterested, could choose not to be educated. That time has almost passed. Civilization, so-called, requires a modicum of education of all fairly normal persons and provides far-reaching opportunities for those of superior capacities. Civilization cares for, as dependents of one kind or another, those incapable or unwilling to gain and use a self-protecting amount and kind of education. Education is a privilege with a strongly inherent element of social compulsion."[48]

Without denying to the citizen of a democracy the right to make his own decisions, and to make of his life what he will, the talented individual still has a heavy responsibility to make the best possible use of his life and his talents.

Society's role of identification and encouragement is no less important. Apart from conflicting ideas about the role of government in the twentieth century, we must recognize the responsibility resting on our local, state, and federal officials to salvage our intellectual resources for good and practical reasons, just as we expect our governmental officials to conserve our wildlife, our natural resources, or our tools of production. Manpower is a misleading, impersonal term but it does have this usefulness: it underscores the power inherent in human abilities. The time when the government and the public could leave to the individualistic whim of philanthropy the development of promising talent is past. Increasing the number of effectively trained talented persons is as fundamental to the national welfare as a host of other government activities.

As Hollinshead has pointed out, it is difficult if not impossible for a family with an income under 3,500 dollars a year to send a child to college without some sort of financial assistance.[49] The device of government scholarship aid for needy, well-motivated high school graduates is a thoroughly orthodox approach to the present shortage of talented men and women. It is simply helping those who would help themselves if they could. It is in the American tradition.

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[48] Henry, *The Education of Exceptional Children*, part II, p. 17.

[49] Hollinshead, *op. cit.*, p. 76.

Deterrents to the production of scientists

Having examined the estimated supply of and demand for scientific talent in this country and having traced the loss of students from high school to college, we may now turn to a consideration of some of the reasons why a nation so wealthy in physical resources and material benefits is not producing more scientists and engineers. What prevents us from having enough persons with scientific skills to go around? What is deterring youngsters of high ability from finding their way into the specialized college graduate labor market? What diverts capable students from entering careers in areas where we need their contributions so badly?

These deterrents might be classified into those pertaining primarily to the individual himself; those related to his family, community, or environmental circumstances; those of a societal nature or based on racial or religious grounds; those reflecting some accepted political or economic policy of the government at either the local or national level; and those reflecting what in oversimplification might be termed the American character. Some of these discouraging factors may be so deeply embedded in our culture that nothing can be done with respect to them in meeting the current crisis. On the other hand, others may be remediable by individual and collective action once we have sufficient knowledge about them to realize the role they play in the loss of our intellectual resources.

One example of a deterrent characteristic of the individual is the unconscious failure to seek out information necessary for the consideration of a scientific career. Few youngsters really know what engineers are or what they do or are aware of the work of a research chemist. Many students find out about technical careers too late to take the high school courses necessary to prepare for them. As Kenneth Boulding has said, "If people are ignorant of their ignorance, there clearly cannot be any demand on their part for knowledge."[1]

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[1] Boulding in National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, p. 23.

Many individuals apparently just take it for granted that they haven't the ability to make the grade.

Another obstacle connected with the individual is the particular type of hero worship engaged in by today's adolescent. The admiration for a Lindbergh or an Edison, the adulation of the scientist or the inventor, seems to have been replaced by new heroes in the young American's mind. The adolescent today seems to revere the baseball star and the television entertainer more fervently than he does the research scientist or engineering wizard. True, space travel has its devotees and there is an adolescent market for science fiction, but the earlier admiration for the scientist in society seems to have been displaced.

Many of the deterrents pertaining to the individual, of course, may be impossible to change. Others, such as attitudes toward education, toward a professional career, or toward hard work in general might be modified through programs designed to acquaint the individual with such matters, provide him with accurate information, and open doors to new interests and abilities which he never dreamed he possessed.

It has been suggested that the peer group with which a child associates can have a strong influence on occupational choice and can turn him either in the direction of college or away from it. In the case studies reported by Berdie, Rothney, Kahl, and others, the influence of a young person's friends on his life plans was frequently apparent. The attitudes and practices of friends can serve to draw youngsters away from scientific and other scholarly careers. Conversely, those whose friends tend to have scientific interests or who take going to college for granted learn attitudes from the group that shape their own. In our project's National Study of High School Students and Their Plans, a clear relationship was apparent between interest in college-going and the number of the student's friends going to college. Among high ability girls, for instance, 76 per cent of those expressing an interest in college said that most of their friends were planning to go to college. Of those who had no such interest only 30 per cent reported that most of their friends were continuing their education.

There are, of course, many strong psychological obstacles which hinder girls from heading toward scientific careers. These obstacles operate to a lesser extent on boys. Frequently, it is not considered feminine for a girl to plan for any specialized training. Althea Hottel, John Dale Russel, and others have described this adolescent feminine attitude toward intellectual achievement and have suggested that it helps explain why many superior girls minimize their academic accomplishments and close their minds against technical or scientific careers in favor of a more passive role in society. In the eyes of friends whose social acceptance they value, it just isn't the thing to do.

On the whole, however, the attitudes and interests of adolescents most closely reflect those of their immediate families; we therefore gain a greater insight into this failure to choose a career appropriate to their abilities by examining the home. The family can of course exert either a positive or a negative influence in shaping interest in science and a professional career on the part of a child in high school. Time and again, authorities in the field have emphasized the very strong influence which the home environment plays in the shaping of children's attitudes toward school, books, subjects like science or mathematics, and occupations which the child will consider. In this respect the economic level, the cultural level, and the extent to which the family values intellectual concerns are three variables which operate to shape a young person's outlook toward schooling and life in general. The Educational Policies Commission has put it this way:

"The child tends to accept the values that predominate among his family and playmates. Children in a cultured home are more likely than others to develop a taste for music, art, and books, and are more likely to want to go to college. Such children are not necessarily superior in ability, but they are more likely to develop whatever abilities they have. . . . The high school youth who develops a strong desire for attending college in the face of the opposition or apathy of his parents is the exception rather than the rule."[2]

Parental influence is so potent a factor because the opinions expressed in the family toward elementary education, homework, and planning for one's future career can mean the difference between success and failure in school, between full utilization of a child's talents or waste of them. Achievement in school or the lack of it has been frequently traced to parental influences or to some aspect of the home situation. Conklin, in writing about failures among highly intelligent pupils, has pointed out that the "personalities of mothers, the discipline employed by the families . . . probably contribute to the failing status."[3] Many of the case studies examined in Rothney's *The High School Student* and much of the data revealed by Berdie's study of Minnesota high school children bear out this point. There were obvious differences in attitude and action between the parents of college-planning children and those of children not intending to go on with their education and these rested in the dissimilar emphasis placed on college and learning in the realization of life plans.

But the differences went deeper than that. Berdie found that while both groups of parents recognized the financial rewards of a college education, the parents of those planning to go to college had stressed the values of higher education for the overall development of their child and had instilled through encouragement and emphasis a certain love of learning which the other group failed to do.[4] Joseph Kahl has also indicated how decisive a role either or both parents can play in this respect.[5]

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[2] Educational Policies Commission, *Education of the Gifted*, p. 26. For additional comments on the importance of the family in this respect see Berdie, *After High School–What?*, p. 49, 144, 173, 176; Hollinshead, *Who Should Go To College*, p. 48; Davis, *On Getting Into College*, p. 13, 16; Bell, *Youth Tell Their Story*, p. 60.

[3] Conklin, *Failures of Highly Intelligent Pupils*, p. 121.

To be effective, however, parental influence must be in the form of encouragement and not in overbearing domination that stifles individual initiative or independent thought. The significance of this factor is revealed in Hollinshead's rough estimate that about half of today's college students are in a particular college because of the influence of relatives or friends.[6] Although we do not yet know precisely to what extent parental attitudes determine whether or not a person goes to college, any programs to increase the number of young people going to college or studying science must take into account the role played by the family either as a stimulant or a deterrent to college-going. As Frank Bowles has pointed out, "It is the home, not the school, which sends people to college."[7]

The effect of the home on the child is also felt in other ways. When parents take an active interest in career decisions, those decisions are more likely to be made early and wisely. When, however, parents take little interest in the child's choice of vocation, the youngster is likely to drift along without much interest or concern in selecting a future career. Where a completely permissive attitude is indulged in and the child is allowed to pick out his own courses in high school without any help, when little more than a "getting by" approach is taken toward studies, the student's selection of an occupation and his development of goals and values is postponed and probably made more difficult. In this connection, the following quotation is worth repeating:

> "The belief prevails that the last people in the world who should exercise any influence on the occupational choice of a youngster are his parents. . . . We strongly believe that his withholding attitude, which may be interpreted by some children as a form of rejection or lack of interest, is evidence that many of today's parents are shirking their responsibility with respect to an area which will have a great bearing on the future happiness of their child."[8]

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[4] Berdie, *op. cit.*, p. 173, 176.

[5] Kahl, "Educational and Occupational Aspirations of 'Common Man' Boys," *The Harvard Educational Review*, vol. 23, no. 3 (summer, 1953), p. 189.

[6] Hollinshead, *op. cit.*, p. 48.

[7] Bowles, "The Future Supply of Scientists," *The Educational Record*, vol. 35, no. 2, (April, 1954), p. 110.

[8] Ginzberg, Ginzburg, Axelrad, and Herma, "The Problem of Occupational Choice," *The American Journal of Orthopsychiatry*, vol. XX, no. 1 (Jan., 1950), p. 192.

Parental action can serve as a deterrent in another way. A parental disregard for high ability can stifle it. A father's dislike for intellectual eminence can thwart a boy's efforts to get good grades. A girl's budding interest in science can be discouraged if, when she asks for a microscope to look at insects and worms, her mother tells her that a girl should be interested in dolls. Distrust for what is different, suspicion of the superior, and an undervaluation of intellectual attainment on the part of the parent can work against a child with high ability.

But the family, of course, is not an isolated segment of the population. Many serious deterrents to the production of scientists can be found in the American community of the 1950's itself.

The size of the community in which one grows up is apparently related to stimulants or hindrances to interest in scholarly endeavors. Visher, for instance, in his latest study of eminent American scientists, has pointed out that a very large percentage of these men were raised on farms and in small villages. Furthermore, in his opinion, a large city seems to inhibit a growth of intellectual interests in a child despite the many cultural attractions available to a family in a metropolitan area.[9] Robert Cook may have the answer to this paradox when he reports that when persons of superior ability move to large cities, they tend to have smaller families and their offspring in turn, enjoying an elevated economic condition, also tend to have smaller families. It is questionable, however, that one should therefore abandon any organized searches for superior talent, as Cook goes on to suggest. He argues that those of superior ability, once discovered and encouraged to rise to their full capabilities, will have smaller families and thus pass on to future generations fewer superior offspring.[10] At any rate, we appear to be caught in a dilemma. Our nation's children are being born in greatest numbers in communities of depressed economic resources where cultural opportunities are frequently the poorest while our ablest individuals are not rearing large enough families to reproduce themselves.[11] It remains to be seen whether the recently increased fertility rate among women who are college graduates will continue and as a result reverse the trend toward a declining intelligence level which Cook discerns.

Insofar as community deterrents to the production of scientists are removable, it will be well to remember that more important than the size of the community is the variety of opportunities afforded for personal and intellectual growth. If the gifted child is given the chance to find his latent talents by the community through support of all varieties of intellectual endeavor, he is more likely to develop those talents. Perhaps Bruce Bliven's words are more a pious hope than a prophecy, "If we can change the attitude of the community as a whole we can benefit the gifted and his parents."[12]

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[9] Visher, *Scientists Starred*, p. 23.

[10] See Cook, *Human Fertility*, pp. 232 ff.

[11] Kennedy, *Education for Democracy*, p. 12.

Examining the societal structure of the United States reveals additional deterrents. There is, first of all, a deterrent to scholarship in the cult of material success that is so strong in our society. Achievement, importance, fame, and even ability are frequently equated with dollars and cents. The child quickly perceives that what really counts in the world about him is wealth and power, not brains. This emphasis on material needs and monetary success is not new by any means. Travelers to these shores ever since the beginning of the republic have frequently commented on the American overemphasis on money and things materialistic. With our continued development, however, this idea has become so firmly entrenched that it takes a strong determination on the part of an adolescent to resist the materialism about him and concentrate on the things of the mind.[13]

Along with this emphasis on worldly success there is another deterrent to the development of scientific ability in American mores—the "cult of mediocrity." Alexis de Tocqueville found it here in the nineteenth century when he reported, "A middling standard is fixed in America for human knowledge. All approach as near to it as they can; some as they rise, others as they descend."[14] Later Edwin L. Godkin discussed it and in our time many educators have pointed out its devastating effect on their student bodies. There is little incentive to the youth of high ability who finds mediocrity so handsomely rewarded in so many walks of life.

Another trait of the American character which seems to become more and more pronounced is the tendency toward conformity. Whether the passion for conformity which appears especially prevalent in our society today is a product of industrialization and standardization or whether it is a postwar reaction to revolutionary, iconoclastic movements abroad in the world is not pertinent to our inquiry. But this urge to conform has a strong influence on the young. Douglas Bray, in his stimulating volume on *Issues in the Study of Talent,* suggests the inhibitory influence of societal conformity on the development and use of higher ability. He points out that what people learn depends upon the particular learning situation and that the child learns the behaviors, skills, values, and attitudes most highly esteemed by the adults around him. When this group exerts particularly strong conformist pressures, the child, a conformist to begin with, tends to find it profitable or safe to learn the culturally approved things and shun those subjects in disfavor with his peers.[15] This point of view is also expressed by David Riesman in *The Lonely Crowd.*[16]

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[12] Bliven, *Preview for Tomorrow,* p. 312.

[13] For the impact of this success motif on the second and third generations of immigrant families see National Manpower Council, *A Policy for Scientific and Professional Manpower,* p. 173.

[14] de Tocqueville, *Democracy in America,* vol. I, p. 55. (New York: Vintage Books, 1954).

One could point to a further characteristic of present-day society which appears to hinder the production of scientists and which also concerns the approved values of the majority. With the growth of industrialization and with the improvement of modern means of communication, the importance of the radio, the motion picture, and television has become very great. Their use, however, as a means of communication has been primarily for purposes of recreation and only secondarily for purposes of learning. We now live in an entertainment-loving society. Making such an observation need not necessarily be a criticism of our culture or of entertainment media. Indeed, the opportunities for educational advancement through television are most promising. But if we are concerned with the factors that encourage young people to take up useful scientific careers, then television shows and the other excellent forms of entertainment we enjoy appear to be opiates. We must remember that there are many things competing for the time of a 16 or 17-year-old. Each hour spent in passive enjoyment of a comedian or cartoon is one hour less that can be devoted to the arduous individual exercise of one's mind. There can be no room in the budding scholar for intellectual softness. As the adolescent finds little encouragement from his society to make the many sacrifices of time, energy, and pleasure necessary to develop his intellectual faculties to the fullest, he makes those sacrifices less and less frequently.

Still another deterrent might be found in the typical American attitude toward science itself. To many Americans scientific activity means applied science, mechanical inventions, and labor-saving devices more frequently than it means pure research. Science becomes a means to another end rather than an end in itself. The scientist, while frequently held in high repute, has less prestige in the United States than he has in Europe and often this prestige is based on what he does (or what others do with his research) rather than on what he is.[17] As Morris Cohen has pointed out, "As a nation, we respect only the practical applications of science and have regard for the efforts of inventors and promoters rather than those of the scientific discoverers."[18]

These traits in the American character, along with others, have produced a number of ironic inconsistencies. Enjoying the fruits of invention and technology to a greater degree than ever before, we have tended to grow more and more suspicious of the men who make that technology possible. Holding the values of a bachelor's degree higher and higher all the time, we have tended to give less and less concern to what went into the making of that degree. Extending wider and wider the circle of those whom we thought should go to college, we have provided a shrinking share of our national wealth for the welfare of higher education. Becoming more and more dependent on the productivity of our scientific development, we have tended to give less and less attention to science courses in our schools. Placing more and more of a burden for bringing up our youth on the shoulders of the teaching profession, we have continued to provide relatively inferior rewards to those in this occupation.

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[15] Bray, *Issues in the Study of Talent,* p. 29.

[16] Riesman, Denney, and Glazer, *The Lonely Crowd,* p. 120.

[17] Recently, for instance, a survey made by the Manufacturing Chemists Association revealed widespread public misunderstanding of the chemical industry. See *Chemical and Engineering News,* vol. XXXII (March 1, 1954), p. 801.

[18] Cohen, *American Thought,* p. 66.

Another deterrent operating to decrease the number of students heading toward scientific careers can probably be found in our handling of the Negro minority in our population. One badly neglected source of intellectual ability, small though it may appear to be, is the Negro youth. The controversy over distribution of ability among Negroes has raged for many years and has served to reveal more prejudice than it has illuminating information. Whether there are serious limits on the incidence of intelligence in Negroes, as some seem to feel, or whether there is no substantial difference in intellect between the children of the two races, as recent studies at Northwestern University seem to support, need not be settled here. It is worth noting, however, that published studies indicate that a large number of Negro children have been found to perform as well on standard tests as the top 1 per cent of white children. There are at least 16 published studies reporting Negro test scores at an IQ over 130. The observations of Martin Jenkins seem particularly pertinent:

> "There appears little doubt that the number of very bright Negro children is relatively smaller than the number of bright white children in the total American population. Nevertheless, it is apparent that children of very superior psychometric intelligence may be found in many Negro populations, and that the upper limit of the range attained by the extreme deviates is higher than is generally believed."[19]

Jenkins has indicated that, of more than 20,000 Negroes examined in 13 studies, the distribution of intelligence was similar to the normal IQ distribution among white American school children. Herbert Carroll, in examining this subject, has concluded that because of factors of inheritance and environment the Negro population in America is 300 times less likely to produce the same proportion of gifted children as the white population.[20]

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[19] Jenkins, "The Upper Limit of Ability Among American Negroes," *Scientific Monthly*, vol. LXVI (May, 1948), p. 400.

[20] Carroll, *Genius in the Making*, p. 22.

With few or virtually no inborn differences in intellectual capacity, the Negro nonetheless is severely handicapped in developing what potential talent he may possess. To begin with, one-quarter of the Negro population is illiterate. Furthermore, the Negro child's attendance in school is not as regular nor as long in duration as that of the white child. His health is frequently poorer, the income of his family lower, and part-time work during his school years more frequently necessary than among his white classmates. In addition, of course, he finds the quality of education afforded him frequently inferior to that provided for white children. In 1952, for instance, an average of 165 dollars in current public school expenditures was spent in the South for every white pupil while an average of 115 dollars was expended for every Negro student. In Mississippi the gap was particularly wide; 117 dollars was spent there in 1952 for every white child and 35 dollars for every Negro student.[21]

What does this mean as far as intellectual accomplishment is concerned? It means that whereas 85 per cent of all white children of high school age in the nation are in high school, only 60 per cent of the corresponding Negroes are enrolled.[22] It means that the number of Negroes graduating from high school in the top quarter of their class amount to about 0.5 per cent of the graduating seniors in all high schools in the nation and the number of Negroes in the top quarter who have completed the minimum requirements for admission to college amount to 0.2 per cent of the nation's graduating seniors.[23] It means that, according to a 1947 study, only about 4 per cent of all college graduates are non-whites and that the Negro enrollment in the nation's colleges amounts to about 3 per cent of the total.[24] It means that the 4,000 Negroes working as doctors make up about 2.2 per cent of all practicing physicians while at the same time Negroes represent one-tenth of our population.[25] It means, as the Educational Policies Commission has asserted, "a shocking waste of talent, a waste that adds an incalculable amount to the price of prejudice in this country."[26]

Some changes in this situation will undoubtedly occur in the future. The work done by such groups as the National Scholarship Service and Fund for Negro Students in studying the problem and in providing information and guidance to Negro youth will bear much fruit. Desegregation in the schools should serve to stimulate college-going. Just as it was discovered in Korea that integrated military units fought better than segregated units, we will probably find that integrated educational units will learn better than segregated ones. The Southern Regional Educational Board has predicted an increase of almost 50 per cent in the Southern Negro high school population between 1954 and 1968. Ferguson's and Plaut's observations suggest that this is one deterrent that with patience and time could be removed:

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[21] Ashmore, *The Negro and the Schools*, p. 153.

[22] National Manpower Council, *op. cit.*, p. 51.

[23] Ferguson and Plaut, "Talent: To Develop or to Lose," *The Educational Record*, vol. XXXV, no. 2 (April, 1954), p. 138.

[24] Havemann and West, *They Went to College*, p. 195; Davis, *On Getting Into College*, p. 79.

[25] National Research Council, Office of Scientific Personnel, *Human Resources and the Fields of Higher Learning*, part IV, p. 15.

[26] Educational Policies Commission, *op. cit.*, p. 33.

> "If these young people knew at the beginning of the ninth grade that scholarship assistance is available to students demonstrating ability and whose scholastic records show adequate preparation for college, it is certain that a far larger number would do better in high school. If the Negro students also knew that on most predominantly white campuses, a really warm welcome awaits them, it would encourage them. If the Negro students knew that an increasing number of higher-level career opportunities are open to them, many of them would raise the level of their educational aspiration."[27]

What has been said about the Negro applies with equal force to the other non-white elements in our population. There are many barriers to higher education for the American Indian, the Puerto Rican, and members of other minority groups. Lack of facilities and lack of knowledge about what opportunities exist for them are two major handicaps facing the children in these minorities. To cite one illustration, Robert Weaver has pointed out that while Spanish-name youth constituted one-fifth of the total white scholastic population of Texas, only between 1 and 2 per cent of those enrolled in 1945 in the state's colleges were of Spanish descent.[28]

In addition to racial deterrents, there appear to have been religious deterrents to the production of scientists in America. In considering ways and means of increasing the number of high school students entering scientific careers, attention must be devoted to the role which Catholicism may play in this respect. Despite the many eminent contributions made to science by Catholic figures, there is some evidence that in the production of scientists American Catholics have been underrepresented in the past. In 1931 Lehman and Witty, examining listings in *Who's Who in America*, published data on the religious background of outstanding scientists. They found that less than 1 per cent of the outstanding scientists listed there were Catholics while 21 per cent were Congregationalists, 20 per cent Presbyterians, and 17 per cent Episcopalians. In terms of proportional representation they found a ratio between Unitarians and

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[27] Ferguson and Plaut, *op. cit.*, p. 139. For an extended discussion of the subject see National Scholarship Service and Fund for Negro Students, *Southern Project Report 1953–55*.

[28] Weaver, *A Proposal for an Undergraduate Supplementary Scholarship Program*, p. 1. See also Fogartie (Ruth Ann), *Texas-Born Spanish-Name Students in Texas Colleges and Universities* (Austin: University of Texas Press, 1948).

Catholics in the production of outstanding scientists of 81 to 0.048. Their conclusion was that this information "shows clearly that the Roman Catholics provide the smallest number of research workers in proportion to their number."[29]

This has been a matter of concern to Catholic educators themselves. In an article in 1945 John Cooper, decrying the dearth of Catholic scientists, estimated that they constituted something under 3 per cent of the leadership in American science as compared with the 20 per cent it should be were it proportionate to the total number of American Catholics.[30] Writing more recently, Julian Pleasants has pointed to steady improvement but has called for a still more representative contribution.[31] The study on the origins of American scientists by Knapp and Goodrich revealed that the productivity index in Catholic universities averaged some 50 per cent higher for the years 1930–41 than for the years 1924–34. Thus, although Catholic institutions ranked in the lowest tenth of the schools in this Wesleyan study, their productivity increased at a time when that of many non-Catholic universities was falling and when the nation-wide ratio of scientists to the total population was dropping sharply.[32]

Knapp and Goodrich suggest the following reasons for the relatively low production of scientists in Catholic institutions:

> "Catholic institutions are in good part concentrated in the eastern industrial sections. . . . The Catholic population of America, from which these institutions have largely drawn their students, has come from parent European cultures not conspicuous in recent times for scientific accomplishments. . . . Catholicism has permitted comparatively little secularization of outlook. . . has been a consistent opponent of physical monism, that philosophical tradition under which science has for the most part advanced."[33]

Other reasons might be added. The Catholic population in the United States has been largely in the middle or lower income group where the college-going tradition in the home has not been strong. The Catholic population in America has been largely urban. Earlier in this chapter it was pointed out that although cities afford great opportunities for persons with scholarly or scientific tastes already developed, a small town or farm environment has been relatively more favorable to the initial development of these interests. Furthermore, Catholic institutions of higher learning have faced severe financial strains in managing the outlays necessary for scientific training and research. This financial stringency has been intensified by the rapid expansion of enrollments in the last few decades.

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[29] Lehman and Witty, "Scientific Eminence and Church Membership," *Scientific Monthly*, vol. XXXIII (Dec., 1931), p. 546.

[30] See Cooper, "Catholics and Scientific Research," *Commonweal*, vol. XLII, no. 6 (May 25, 1945), p. 148.

[31] Pleasants, "Catholics and Science," *Commonweal*, vol. LVIII, no. 21 (Aug. 28, 1953), pp. 509–514.

[32] Knapp and Goodrich, *Origins of American Scientists*, p. 15, 24, 260, 288, 329–330.

[33] *Ibid.*, p. 288. For a consideration of the role of Protestantism in the development of science, see Merton (Robert K.), *Social Theory and Social Structure* (Glencoe, Ill.: Free Press, 1949), pp. 329–346.

Whether the intellectual atmosphere of Catholicism in America is unfavorable to the development of science is a complex question. The inquring, doubting mind, the ceaseless searching for truth by empirical means, the constant discontent with all forms of subjectivity and authority which characterize the scientist may well be incompatible with the views or the philosophy of education of the Catholic Church. At the same time, recent studies in the history of science show clearly how complex are the origins of the scientific age, how continuous was the tradition of experimental science with its roots in medieval culture, and how close was the connection between the Catholic intellectual tradition and the development of early modern science. The activity of the Papal Academy of Science, honoring scientists of all countries and creeds, and the encouragement of science in recent papal encyclicals, such as *Humani Generis* in 1950, illustrate how difficult it is to generalize about Catholicism and scientific activity.[34] The conclusion of Lehman and Witty that "the conspicuous dearth of scientists among the Catholics suggests that the tenets of that church are not consonant with scientific endeavor" is a questionable point.[35] Cooper's words that "from the whole staff of many a Catholic college in the United States there is issuing at present hardly a creditable paper a year" seem a self-indictment which is overly critical.[36] One writer has suggested a course for future Catholic scientific development: "Catholic scientists can work with other Christians in strengthening and extending the City of God without contributing too much toward the triumph-in-decay of the secular city that is at war with it."[37] Whatever our point of view, it is well to remember that while it was the Catholic Church that made Galileo recant, it was American Protestant fundamentalism that fought with equal bitterness if not equal potency against the massive scientific evidence of evolution. It is also quite possible that religion can serve as a stimulant to scientific activity as well as a deterrent.

A number of other deterrents might be found in the existence of federal and state policies which are inimicable to the production of scientists and engineers. Although our current immigration policy may not appreciably affect production of them within the nation, there appears to be ample evidence that it is restricting the importation of persons with skills badly needed by our economy. As observed earlier, an easing of our federal immigration laws should have a beneficial effect on the supply of specialists. Individual state policies frequently act to restrict supply. In this respect, the National Manpower Council has reported:

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[34] See Crombie (Alastair C.), *Augustine to Galileo, The History of Science, A. D. 400–1650.* (Cambridge: Harvard University Press, 1953); Moody (Ernest A.), *Truth and Consequence in Mediaeval Logic* (Amsterdam: North-Holland Publishing Co., 1953); Boehner (Philotheus, father), *Medieval Logic* (Chicago: University of Chicago Press, 1952).

[35] Lehman and Witty, *op. cit.* p. 549.

[36] Cooper, *op. cit.* p. 149.

[37] Suger, "Problems of the Catholic Scientist," *Catholic World*, vol. 176 (Jan., 1953), p. 283 n.

> "At the close of World War II, there were over 500 state laws which limited certain occupations to American citizens or to aliens who had filed their first papers. Today, almost thirty states bar aliens from the practice of medicine, while almost as many require full citizenship for the practice of law. Similar restrictions affect pharmacists, teachers, dentists, nurses, engineers, and still other professional persons. Thus, the influence of professional societies and nationalist sentiment has deprived the country of the skills and capacities of many highly trained aliens."[38]

Many scientists have critized the national loyalty and security restrictions for their damaging effect on the profession. Ever since the end of World War II, scientists have found themselves on the defensive, condemmed as a group for the activities and ideas of a few and probably subjected to more scrutiny and harassment than any other segment of the population. Periodically, individuals and scientific organizations have criticized the governmental attitude toward them and have underscored the necessity for greater freedom of action and movement if scientific inquiry is to progress. Typical was Dr. Vannevar Bush's warning to a Congressional committee in 1954 that the government's security risk program had hindered weapons research and in general had demoralized scientists. Characterizing the orders on loyalty and security as "poorly conceived . . . poorly interpreted" he declared that "scientists today are discouraged and downhearted and feel that they are being pushed out."[39] Harry Cain, a member of the Subversive Activities Control Board, recently declared that the United States had a security system which could "snuff out the lights of learning while making cowards and mental robots out of free men and women."[40]

In attempting to prevent leaks of important information to a possible enemy and in rooting out subversion, apparently it has been overlooked that a certain minimum freedom of inquiry is essential to maintain a productive scientific atmosphere, that secrecy is not in the tradition of the scientific method. Recently, Henry De Wolfe Smyth declared that scientists "must remind military and political leaders that the strength of science is based on freedom of inquiry, freedom of discussion and freedom of dissent."[41] In addition to the loss of scientific freedom, there has been a serious decline of morale. The knowledge that 30 persons were refused Public Health Service grants in the period from 1952 to 1954 because of derogatory information is distressing to those who may apply for funds in the future, uncertain what events in their past may be dredged up to ruin their careers. As one scientist has put it, "No one knows what political criteria are being used by administrators who make such decisions behind locked doors—without consultation with representatives of the scientific community, without any formal procedure, without offering any recourse of appeal for those who have been blacklisted."[42] The insecurities of the times should not blind us to the need for greater freedom for our scientists if they are to work effectively. It is well to ponder A. H. Maslow's observation, "Tradition in science can be a dangerous blessing. Loyalty [in science] is an unqualified peril."[43] Whether the existence of loyalty checks and security clearances have operated to deter high school students from entering scientific fields is difficult to say. Today's adolescents are far more well-informed than we realize and this may well become a serious deterrent if improvements are not made in this area.

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[38] National Manpower Council, *A Policy for Scientific and Professional Manpower*, p. 247.

[39] *The New York Times*, Oct. 19, 1954.

[40] Quoted in *The Reporter*, vol. XII, no 3 (Feb. 10, 1955), p. 4.

A number of persons have also pointed to our selective service policy as a possible deterrent to the production of scientists and engineers. By and large we have been fortunate to have developed a selective service policy which operates successfully through local draft boards with fairness and some flexibility. The universality of military service and the provision of postponement but not exemption for good cause have been in the democratic tradition. There is a growing sentiment, however, that this policy is seriously deficient insofar as the supply of scientists and engineers is concerned. Despite the shortages in these fields, we are still diverting trained technical graduates into uniformed service in which there is waste through inefficient utilization of their skills. We appear to be still preparing to fight World War II. Some local selective service boards apparently fail to comprehend the value to the defense effort of a physicist or an engineer.

This is a very difficult problem to resolve. We must avoid change in policy that would reflect favoritism to particular groups but on the other hand we must avoid practices that bring about indiscriminate waste of talent. The seriousness of this dilemma was underscored by the Committee on Manpower Resources for National Security when it wrote, "The problem of distributing men of highly developed skills between military and supporting civilian activities has greatly increased during the past decade. Proper distribution of men having these skills has become a major factor in achieving our greatest national strength."[44] A possible solution may be found in liberalizing our attitude toward what constitutes military service. If a research chemist is put in uniform and placed in a laboratory rather than taught close-order drill, the national defense effort will surely be more enhanced.

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[41] *The New York Times,* Jan. 29, 1955.

[42] Quoted in White, "U.S. Science: The Troubled Quest," *The Reporter,* vol. XI, no. 5 (Sept. 23, 1954), p. 34.

[43] Maslow, *Motivation and Personality,* p. 18. For a more extended examination of the loyalty and security issue see Price, *Government and Science,* pp. 95 ff.; Gellhorn, *Security, Loyalty, and Science;* and Simon, *The Neglect of Science,* p. 34. Scientists' attitudes toward working for the federal government are outlined in Steelman, *Science and Public Policy,* vol. III, pp. 142 ff.

The seriousness of the selective service picture can be seen by examining a few figures. At present it is estimated that about one-quarter of the nation's scientists and engineers are members of military reserves.[45] The percentage varies in different fields. About 15 per cent of all chemists probably are reservists. Among the younger chemical engineers the proportion is nearer 33 per cent.[46] Recently selective service regulations were changed so that now deferment of students entering graduate schools is restricted to the top quarter rather than the top half of the senior class in each college. Howard Meyerhoff has asserted that our shortage of scientists has been aggravated by the induction into service of about 22 per cent of the male graduates who have earned teaching certificates in science. He has also indicated that in December 1953 only 0.3 per cent of those available for military service were deferred for industrial work while at the same time the United Kingdom was deferring 4.8 per cent of its men of military age for reasons of national welfare.[47] Just how many of the estimated 50,000 engineers and scientists now in uniform are working at their specializations is difficult to estimate. Henry Armsby has reported on one study which recently revealed that only 70 per cent of the men in uniform who held graduate degrees in physics, chemistry, and related sciences were making direct use of their specialized training in the service.[48] As Ginzberg and Anderson have stated:

> "Since the Korean outbreak the numbers enrolled in ROTC programs have increased rapidly. Many units are located at engineering and technical schools,

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[44] United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *Manpower Resources for National Security*, part V, p. 6.

[45] United States Office of Defense Mobilization, Committee on Manpower Resources for National Security, *op. cit.*, part V, p. 5.

[46] United States Department of Labor, Bureau of Labor Statistics, *Manpower Resources in Chemistry and Chemical Engineering*, Bulletin No. 1132, p. 3, 6.

[47] Meyerhoff, "Arms and Manpower," *Bulletin of the Atomic Scientists*, vol. X, no. 4 (April, 1954), p. 119.

[48] Armsby, *Scientific and Professional Manpower*, United States Department of Health, Education, and Welfare, Office of Education, Circular No. 394.

for the senior military commanders have long been impressed with the quality of engineering and science graduates. The expansion of the program reflected these facts with the result that a large percentage of the total undergraduate student body in engineering and the sciences is now enrolled in the ROTC. Since the services consider ROTC graduates the primary source of junior officers, they are in general disinclined to agree to any deferment beyond college graduation. There is a real possibility, therefore, that the future supply of advanced science and engineering graduates will be adversely affected, for many men will not wish to return to school after two or three years on active duty."[49]

The many warnings by authorities that we are wasting talent in our present selective service policies should not go unnoticed. The most valuable book on this subject is M. H. Trytten's *Student Deferment in Selective Service*. Dr. Trytten has expressed the opinion that when it is obvious that an individual with special training can best serve the nation in a nonmilitary post, he should not be required to serve under arms.[50] Albert Blum has come to the conclusion that it is completely wasteful to draft toolmakers, lens grinders, engineers, and atomic scientists unless they are going to work at their specialties while in the service.[51]

The words of Representative George H. Bender underscore the necessity for improving our present policy. In 1953 he declared, "Certainly any policy which depletes our reservoir of scientific personnel is short-sighted and unforgivable, whether it be undertaken by military or any other priority groups."[52] In this respect, the experience of Great Britain in World War II might be carefully considered. In 1939, after Britain's registration of all scientific manpower, no scientist could join the services without special permission. A reservoir of specialized persons was then built up to be transferred when needed on a discriminating basis.[53] This would seem an appropriate time to view service in terms of highest capacity or most efficient utilization rather than the wearing of the uniform. We would do well to remember that even during the Battle of Stalingrad the Soviet Union did not take scientists into the army.

Our selective service policy is not the only manifestation of our democratic principles which acts as a deterrent to the development of trained scientists and engineers. In addition to the many beneficial aspects of what Godkin called our "passion for equality" which we as a nation cherish and are determined to defend, there is a certain emphasis in the democratic view which penalizes talent. The equalitarian tradition, derived from Jacksonian democracy, when misapplied, has been likely to assume the proposition that abilities are equal and that intellectual talents do not deserve to be respected or rewarded. In such an interpretation, as Merle Sumption has pointed out, there was no room for special education of the gifted, who frequently were resented and misunderstood.[54]

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[49] Haber, Harbison, Klein, and Palmer, *Manpower in the United States: Problems and Policies*, pp. 178–179. In 1955, approximately 7,200 (or one-third) of the nation's engineering graduates were members of ROTC units.

[50] Trytten, *Student Deferment in Selective Service*, p. 29. See also Quattlebaum, *Educational Aspects of Universal Military Training*, p. 277.

[51] Blum, "Deferment from Military Service: A War Department Approach to the Solution of Industrial Manpower Problems," unpublished Ph.D. dissertation, p. 509.

[52] *Congressional Record*, vol. 99, part II (May 5, 1953), p. A 2,840.

[53] See Appleton, "Science, Industry, and Government," *Technology Review*, vol. 49, no. 4 (Feb., 1947), p. 211.

In recent times there has been considerable criticism of this doctrine. The Educational Policies Commission has declared:

> "In our days of 'Jacksonian democracy' the false doctrine gained currency that any man is as able as another. This idea still has a great hold on the American people in spite of its patent fallacy—attested by both the common-sense conclusions from everyday observation and the data of psychology. Yet, there persists a tendency to idealize the average man and to belittle the exceptional man."[55]

Echoing these words, T. R. McConnell, a member of President Truman's Commission on Higher Education, has declared, "It is not undemocratic to recognize and nurture exceptional talent. Our society needs all the talent it can find. But I do not believe that quantity and quality are incompatible."[56]

Connected perhaps with this Jacksonian tradition, but more widespread than a mere denial of ability differences, there has developed in this country a movement which for want of a better term has been called anti-intellectualism. This also serves as an obstacle to the creation of scientists and other scholars. Anti-intellectualism, in its negative aspect, fixes upon those who are scholars, teachers, research workers, and writers a low prestige and a relatively poor scale of remuneration for their services. The status of the intellectual has been the subject of much discussion recently. In his last book Morris Cohen wrote, "In no other country is the word intellectual so often used as a term of derision and opprobrium."[57]

One can see this attitude toward the intellectual revealed in many ways. The stereotype of the scientist as an odd character in television scripts, the portrayal of the absent-minded professor in motion pictures, and the glorification in our newspapers and magazines of those qualities of behavior inimicable to the pursuit of knowledge come most readily to mind. The attitude toward knowledge and its use reveals the low esteem in which our nation holds the scholar. It was F. E. Simon who exclaimed, "Some people are even proud of their ignorance of science."[58]

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[54] Henry (ed.), *Adolescence*, p. 260. See also Witty, *The Gifted Child*, p. 89, and Godkin, *Problems of Modern Democracy*, p. 87.

[55] Educational Policies Commission, *op. cit.*, p. 11.

[56] McConnell, "A Reply to the Critics," *Journal of Educational Sociology*, vol. XXII, no. 8 (April, 1949), p. 107.

[57] Cohen, *American Thought*, p. 27.

The most tangible way to chart this attitude is to examine the monetary rewards offered to those who enter intellectual professions. Teachers' salaries continue to be ridiculously low, despite some recent increases in pay scales. In some fields of research, it is true, relatively high salaries have been offered of late. Bureau of Labor Statistics figures reveal, for instance, that the median income of chemists in 1951 was 5,500 dollars.[59] But here, too, we see the greater emphasis placed on applied work rather than on pure science. In the colleges and universities, where much of the basic scientific and other scholarly activity must continue to be centered, low salary scales clearly indicate what society's opinion of the academician is. The following table graphically illustrates the monetary value society has placed on different occupations requiring high-level ability.

Men college graduates earning more than $5,000 a year in 1947[a]

Occupational field	
Business administration[b]	82%
Medicine	71
Law	63
Dentistry	63
Engineering	52
Government service	38
Science	26
Education	19

[a] Source: Havemann and West, *They Went to College*, p. 33, 36, 149.
[b] Executives over age 40.

A few years ago, Clarence Long pointed out that the average full professor at Johns Hopkins University in 1952 had one-fourth less purchasing power than in 1940, even before higher income taxes were taken into account. He warned that if this situation continues, the number of able young persons willing to undertake graduate work in the professions will decline and more teachers will seek employment outside of the classroom. In his opinion, "the long-term trend is unfavorable to all learned occupations."[60] Occasionally a scholar will cry out against the prevailing current of opinion and neglect:

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[58] Simon, *The Neglect of Science*, p. iii.

[59] United States Department of Labor, Bureau of Labor Statistics, *Manpower Resources in Chemistry and Chemical Engineering*, Bulletin No. 1132, p. 5.

[60] Long, "Nothing to Lose but Its Brains," *The Johns Hopkins Magazine*, June, 1952, p. 27.

"Nowhere in the world do the scholar and the learned man understand how to secure the position and the pay that they deserve. . . . Do I have to remind you of the disgraceful fact that the compositor often gets more pay for setting up a book than the author gets for writing it? . . . Are we scholars only for philanthropic purposes? . . . The exploitation of the scholar is one of the worst in the world. It is the modern social problem! Nobody bothers about it, not even the scholars themselves."[61]

Usually, however, the scholar accepts the community's unconcern with his work, society's neglect of his well-being, and mankind's ignorance of his true worth. The place given to higher education best illustrates this. Colleges have never been more crowded than during the last 10 years. Society has never expected more of its members to secure a higher degree than it does now. Yet the aspects of college life which are the farthest removed from the things of the mind are given the greatest public attention. Athletic spectacles, the social side of campus life, and the acquisition of vocational, "practical" information are frequently the aspects of college most emphasized by the public at large. Individuals readily pass judgment on university policies, denying that expert opinions of specialists need be given any weight. Organizations frequently do not hesitate to influence the activities centered in college campuses without regard to the intellectual freedom those campuses are supposed to enjoy. It is our custom to speak of a doctor's "orders" but of a scientist's "opinions."[62]

If this low opinion of intellectuals had only its negative aspect, it would not be too serious a deterrent. But there is a positive aspect, revealed by the suspicion in which intellectuals are held and by the hostility exercised against them. It has been pointed out that criticism of the New Deal and its Brain Trust, coupled with our struggle against Communism, account for the intensification of anti-intellectualism in this country. The attitude seems to go much deeper than that, however. The dislike of something unknown or unappreciated, the hostility toward the critic or the innovator, the insecurity of an age whose accomplishments have made it economically and politically more and more interdependent, and the deep-rooted reaction against the minority in our midst, all help "explain" the continual rise of this curious phenomenon in a country that has benefited so greatly from the achievements of its intellectuals. David Riesman, in his provocative *Individualism Reconsidered,* has suggested that the very increase in the number of intellectuals themselves accounts for some of the venomous attacks against them, that the relative rise in the status of the "drummers of ideas" compared with that of the businessman and politician explains some of the opposition to them, and that the practical man resents the intellectual for his growing influence. In his opinion, a new type of status warfare has replaced the old class struggles.[63]

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[61] Bodewig, "Payment of the Learned Men," *Science,* vol. CXII (Nov. 3, 1950), p. 538.

[62] For similar views on this subject see Cohen, *op. cit.,* p. 33; Dodds, Hacker, and Rogers, *Government Assistance to Universities in Great Britain,* p. 105; Wolfle, *America's Resources of Specialized Talent,* p. 282.

This anti-intellectualism is paradoxical in that it frequently goes hand in hand with a high regard for science, with a reverence and glamor often associated with creative endeavor. It is inconsistent with the great enjoyment in this country of the products made possible by the technology resulting from the scholar's work. Indeed, it may even be ironic in that it becomes a type of safety-valve for the pent-up passions of the unthinking millions who must find some outlet for their antagonisms and insecurities.[64]

Examination of this phenomenon is justified because of its impact on science and scholarly endeavor. Money spent on scholarships, efforts taken to improve the quality of teaching, and programs initiated to provide children with more information about scientific careers will all go for naught if this self-destructive attack against the intellectuals in our society is not checked. The seriousness of this matter was emphasized in a *New York Times* editorial on "The Anti-Intellectual:"

> "When anti-intellectualism takes hold of a nation, that nation is in danger. Reason, understanding, and the disinterested search for knowledge become the exception; passion, dogmatism, and brutal conformity become the rule. Anti-intellectualism in America is certainly not the dominant force, but it is strong enough, and has received sufficient encouragement, to warrant . . . concern."[65]

This wave of anti-intellectualism has taken its toll among scientists already established in their profession. The greater impact on those who will never train to become scholars because of it is impossible to measure.

There are, of course, other deterrents which will come to mind. Many speak of the obstacles to scientific achievement existing in the educational institutions themselves, in the classroom, in the lack of sufficient guidance facilities and in the poor teaching which is reported in some of our schools and colleges, and in an educational philosophy that seems to stress "adjustment" rather than "achievement" and mediocrity rather than excellence. Since there are, however, important encouragement factors to producing scientists in the educational scene, we shall examine the schools in terms of what they do and can do to further the cause of high scholarship rather than consider out of context only their present weaknesses as so many critics prefer to do. It is to the present and potential attractions that we shall now turn.

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[63] Riesman, *Individualism Reconsidered*, p. 127.

[64] For further consideration of this paradox see Educational Policies Commission, *op. cit.*, p. 11; National Manpower Council, *op. cit.*, p. 256; Price, *Government and Science*, p. 25; Riesman, *op. cit.*, p. 44, 135.

[65] *The New York Times*, Sept. 11, 1954.

Potential factors encouraging careers in science

Having examined some of the many deterrents, let us now consider some of the special efforts being made in America today which directly or indirectly attract young men and women into scientific careers and then examine those aspects of American life which in the natural course of events are mainly responsible for producing scientists, what their past performance has been, and how it could be improved. Impressive programs aimed at interesting boys and girls in science are conducted by various professional societies and industrial corporations; how extensive and effective have these programs been? How do present federal government activities in support of scientific endeavors indirectly affect the career interests of America's youth? What effect does the home, the community, the school, and even the popular culture of the nation have in leading boys and girls into scientific careers? At what points in American life might greater public support most productively influence more youngsters to become scientists and engineers? These are some of the questions this chapter will attempt to answer.

In the nation at large there are many formal programs supported by professional organizations, business firms, and other agencies which serve to encourage students toward careers in science. As early as 1923 the American Chemical Society conducted a prize essay contest for high school students to encourage them "to know more about chemistry" and "to realize the cultural value of such study."[1] There are currently over 50 science incentive programs sponsored by private and public organizations, the best known of which include the Bausch and Lomb competition, state science fairs, and the essay contests of the various professional societies. The widely successful Science Talent Search conducted by the Science Clubs of America and sponsored by the Westinghouse Educational Foundation is another example of an effort to find high school seniors with the highest aptitude for scientific careers. It has been asserted that the very existence of the contest and the interest in it on the part of teachers and students spur many students on toward science studies.[2]

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[1] Howe, "Report of the Committee on Prize Essays of the American Chemical Society," *Journal of Chemical Education*, vol. II, no. 1 (Jan., 1925), p. 3.

The high average of Science Talent Search winners who go on to do graduate work in science is significant evidence of its usefulness and of the high predictability of its tests. However, such contests frequently identify promising students only at the twelfth-grade level, when many have already been lost to higher education and the scientific professions. Furthermore, their effectiveness depends on wide coverage and unfortunately some high school teachers do not want to get involved in the work associated with them. In a recent canvass of 425 teachers, only 40 per cent reported that the Talent Search program was operating in their schools.[3]

Another approach is the one used by Science Service which through its Science Clubs of America cooperates with other organizations in assisting some 15,000 science clubs throughout the nation. The clubs take part in science fairs and various kinds of science programs. Watson Davis has estimated that over 330,000 young people are enlisted in science club work.[4] A new program for encouraging students in science was inaugurated in 1954. Sponsored by the American Society for Metals and conducted by the Future Scientists of America Foundation of the National Science Teachers Association, the program made available 104 student awards totaling 5,000 dollars. In addition, the American Society for Metals makes awards to teachers for reports on effective ways of working with students to stimulate interest in science.[5]

One of the most important organized efforts on behalf of science and engineering recruitment has been the one conducted during the last few years by the Engineering Manpower Commission of the Engineers Joint Council. In 1952 the Commission attempted to publicize the decreasing enrollment in engineering colleges and the increasing career opportunities in the profession. Circulating material to guidance counselors and secondary school principals, the Commission conducted a vigorous campaign.[6] Henry Armsby has compared enrollment figures in 1953 with those in 1950 and has pointed out that the number of all college freshmen increased 11 per cent while the number of engineering freshmen increased 76 per cent. In 1950 only 6.6 per cent of all freshmen were pre-engineers. In 1953 the proportion was 10.5 per cent.[7] Although this increase was not the result of its work alone, the Engineering Manpower Commission can take credit for a portion of that increase.

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[2] Davis, "Test Your Science Aptitude," *Science News Letter,* vol. 63, no. 4 (Jan. 24, 1953), p. 58. For a listing of the principal professional and governmental agencies concerned with encouraging the production of scientists see Armsby, *Scientific and Professional Manpower, Organized Efforts to Improve Its Supply and Utilization,* United States Department of Health, Education, and Welfare, Office of Education, Circular No. 394.

[3] Woodburn (John H.), in Future Scientists of America Foundation, *Encouraging Future Scientists: The Situation* (Washington: Future Scientists of America Foundation, National Science Teachers Association, 1953), p. 5.

[4] Davis in Witty (ed.), *The Gifted Child,* p. 241.

[5] Chase, "1953 Winners of Science Achievement Awards for Students," *The Science Teacher,* vol. XX, no. 4 (Sept., 1953), p. 192; Hale, "Winners in 1953 Program of Recognition Awards for Science Teachers," *Ibid.,* p. 202.

[6] The most informative booklet in this field for high school students appears to be *Engineering, A Creative Profession,* issued by the Engineers' Joint Council for Professional Development (29 W. 39th St., New York, N. Y.). The Scientific Manpower Commission is currently studying vocational guidance literature to ascertain its adequacy and to inform guidance counselors of its availability.

Programs for encouraging science teachers as well as students can serve as important spurs to the future production of scientists and engineers. Excellent work in this direction has already been done by the Future Scientists of America Foundation of the National Science Teachers Association.[8] Twenty-four universities now have summer programs giving high school science teachers work as research assistants to prominent scientists. Summer institutes, short-term courses covering what is new in the field, and vacation workshops have been sponsored by General Electric, Westinghouse, and other corporations.[9] Over 25 industrial organizations have now established regular summer work programs for high school science teachers which provide them with experience in the industrial laboratory as well as much needed extra income. The Kanawha Valley Section of the American Chemical Society, for instance, has been instrumental in securing summer employment for high school science teachers in its West Virginia area. Enthusiastically received by the teachers involved, this summer work experience has served to supplement inadequate teaching salaries, stimulated the teachers' enthusiasm, and provided them with practical experience in industry which should enhance their instruction.[10]

Sometimes such programs backfire when a teacher, finding how much more he can earn in industry, decides not to return to the classroom when summer is over. A program of summer financial rewards without formal employment, however, should pay off in keeping teachers up to date on recent scientific developments and in providing them with additional financial recognition. In this respect, it would be well to note that the high school science teacher whose main specialization is outside the field of science also needs attention and help. A program of information and support designed to aid primarily those who find themselves teaching science as a second subject seems advisable.

Any effort that can be made to provide encouragement and intellectual stimulation to high school teachers should be undertaken. A number of professional societies invite outstanding teachers and students to meetings where the advantages of science careers are discussed. The Cooper Union in New York brings together high school mathematics teachers in the city to discuss common problems. Local committees of college and high school science teachers could serve to improve mutual understanding and provide a common front for meeting the crisis. The summer employment of promising high school students in the Roscoe B. Jackson Memorial Laboratory in Maine is another useful devide for encouraging research careers. The program of the American Association for Gifted Children is an outstanding example of work being done in another direction.[11]

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[7] Armsby, *Scientific and Professional Manpower*, pp. 11, 12. 38–39.

[8] See Future Scientists of America Foundation, National Science Teachers Association, *Encouraging Future Scientists: The Situation; Materials and Services Available in 1954–55;* and *Careers in Science Teaching*, (1954).

[9] See *Bulletin of the National Association of Secondary-School Principals*, vol. 37, no. 191 (Jan., 1953).

[10] K. L. Godfrey (chairman, education committee, Kanawha Valley Section, American Chemical Society) to John H. Woodburn (assistant executive secretary, National Science Teachers Association), October 22, 1954.

Another program which might serve to encourage science careers would be one which sent excellent lecturers to different parts of the country to speak to high school teachers and student audiences. Such men, if they were stimulating speakers, might create more interest in the high schools and in communities at large in science careers, manpower utilization, frontiers in engineering, and vocational planning. Emerson's lecture tours and the traveling Chautauqua were strong influences in their day. New printed material, tested on students and science teachers, is probably also needed.

The government is another institution which can help to encourage careers in science. Several recent studies have examined the role of the federal government in encouraging the pursuit of science and the problems involved in governmental activity in this area.[12] These studies indicate that federal support of education is not new by any means and that there is a long tradition of governmental interest and concern with special areas of educational and scientific activity either because these areas have been neglected or because concern for them has been in the national interest. In the past, federal programs have tended to fall into certain categories, have emphasized vocational and professional aspects of education, and have supported applied research and education rather than the more fundamental variety. Federal support, generally, has singled out special groups in need of encouragement. It has developed on what Hollis Allen has called a "piecemeal" basis and has been singularly free of direct control over education.

The extent of federal support on behalf of science is impressive. Around 1900 federal expenditures for research and development were between five and 10 million dollars a year. As reported earlier, by 1930 they were 23 million dollars. By 1945 the figure was one billion dollars and it had reached two billion by 1953.[13] Put another way, the federal government's portion of all expenditures for research and development amounted to about 40 per cent in 1941, 70 per cent in 1945, and 60 per cent in 1952. A twentyfold increase in federal government expenditures in this area took place over a 12-year period. Another measure of the support of science by the federal government can be seen in the fact that in recent years approximately one-half of the industrial research scientists and engineers in the country have been working on government-financed projects.[14]

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[11] The following books discuss this subject at greater length: Burnett (ed.), *Selected Science Teaching Ideas of 1952;* Henry (ed.), *Science Education in American Schools*, 46th Yearbook of the National Society for the Study of Education, part I.

[12] See especially Price, *Government and Science;* Axt, *The Federal Government and Financing Higher Education;* Allen, *The Federal Government and Education;* Russell, *Federal Activities in Higher Education After the Second World War;* Quattlebaum, *Federal Aid to Elementary and Secondary Education* and *Federal Educational Activities and Educational Issues Before Congress.*

Of course, a great deal of governmental support recently has been directed toward applied military research. Almost 98 per cent of the 338 million dollars spent by the government in research and development undertaken by educational institutions in 1951–52 was spent by four agencies, the Department of Defense, the Atomic Energy Commission, the Federal Security Agency, and the Department of Agriculture.[15]

What about future governmental support? It would appear that the long-term trend toward increased financial commitment will probably continue. The emphasis probably will shift somewhat towards more support for basic research in the sciences. The pressing needs of elementary schools for financial aid will probably result in an increased emphasis in this area, perhaps at the expense of higher education. The federal government's concern for an adequate public school construction program reflects this. In this respect, it is well to note that while education has historically been considered the domain and responsibility of the states, state expenditures for higher education amounted to 10 per cent of all state expenditures in 1915 but only 4 per cent in 1949.[16]

Whether any control accompanies governmental support is an issue to which educators, government officials, and the public are alert. The American educational and constitutional systems appear to provide salutary checks to any marked increase in overt control exercised by the federal government or any of its agencies. What is more crucial appears to be subtle types of indirect control which are difficult to assess. For instance, as Hollis Allen has pointed out, the sum total of federal research programs channeled in the physical science fields may result in an educational emphasis in staffing and curriculum which would act to the detriment of the humanities fields. Because of its diversity and variety, higher education probably lacks any built-in stabilizer that would operate to check any undue or disastrous overemphasis in a particular discipline.

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[13] Price, *op. cit.*, pp. 35–36.

[14] Stern, "Freedom of Research in American Science," *Science and Society*, vol. XVII, no. 2 (spring, 1954) pp. 107–108.

[15] Gant and Rubenstein, "Funds for Science," *Science*, vol. CXVII (June 19, 1953), p. 670.

[16] Axt, *op. cit.*, p. 208.

The institution of the government as an encouragement factor, therefore, is potentially powerful. The consensus of opinion among educators appears to be that efforts to stimulate careers in science should be carefully considered and undertaken with a view toward their effect on other areas of intellectual endeavor. Hollis Allen's words are worth repeating:

> "There is definitely a competition for the brains of America to an extent which has never previously existed. It is important for the well-rounded growth of America that no one individual group or calling be given too great an advantage in this competition. The federal government must not permit itself to become a party in such a situation."[17]

While industry and government play significant roles, it goes without saying that they do not perform as important functions as the home, the community, the school, and even the popular culture in attracting the child to a field of scientific and scholarly endeavor. Any American child would learn of science today through the popular culture even if it were to be ignored by everyone in his or her immediate environment. Magazines, broadcasts, movies, newspapers, and books frequently dramatize those scientific achievements which have had an immense effect on modern life. Publicizing of the many valuable contributions of scientists to the winning of World War II and to the subsequent defense effort has attracted young persons to the scientific professions. Stories about atomic energy, penicillin, jet propulsion, and artificial chemical photo-synthesis have glamorized research and invention. The very importance of scientific progress to our survival has emphasized the prestige of science as a career in the minds of many young people.

However, the very glamorization of science has tended to give the schoolboy a distorted picture of scientific activity. When he considers what a scientific career might be like, today's schoolboy will think of atomic explosions rather than routine research; trips to the moon rather than undramatic concentration within the confines of a laboratory. Because of this glamorization and an accompanying glorification of the great scientist, youngsters tend to dismiss science as a career because they are led to believe that it requires the ability of a genius and are left in ignorance of the more mundane scientific work for which they might be fitted. But there is still no denying that the pervasiveness of science in the popular culture fires and feeds the interest of many a youngster.

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[17] Allen, *op. cit.*, p. 154.

As a result of the dramatic portrayal of scientific accomplishments in the popular press, scientific kits or sets for children have long been widely manufactured and sold. This educational play equipment acquaints children with a little of the tools, materials, and phenomena of such fields as chemistry, electronics, geology, optics, mechanics, and zoology. But these playthings that have become a part of our popular culture, though useful enough, can hardly be expected to encourage a deep devotion to science and scholarly endeavor.

In influencing children to consider going to college in general and entering scientific careers in particular, however, the role of the popular culture is minor compared to the role of the home. How the family can decisively affect the college-going and career decisions of young people has already been discussed in the preceding chapter. To our remarks in this connection we would like to add only the observation of Stephen Visher that, if our society is to increase the number of its most productive individuals, more children must be born and raised in those families which are potentially able, both genetically and culturally, to produce intellectually superior offspring. In Visher's view, disaster awaits a people that leaves its reproduction to those who are biologically or culturally unfit.[18]

We have also examined in the previous chapter the important influence the community apparently has on the college-going and career decisions of young people. These remarks may be appropriately amplified here by noting the kind of communities and social classes in the nation among which future selective or local efforts to encourage scientific talent might be most profitably conducted. Scientists in the past seem to have come most often from cities and towns where alert, energetic, and resourceful families were likely to be found —from college towns, county seats, state capitals, and the suburbs of the more prosperous cities. A striking proportion of scientists has also been raised in small towns in agricultural regions of the Middle West. Among occupational groups, the children of ministers seem to embark in large proportions on scholarly careers. And certain values of the middle class serve as strong stimuli to the production of scientists, as Nelson Henry has well stated:

"The 'small people' in the middle groups are the backbone of our society; the 'upper middles' are the brain and the eyes of the society. Almost all of the good things in American life, as we in education evaluate it, are the achievements of the middle-status persons; care of and pride in property, careful child-training with emphasis upon renunciation and sacrifice for future gains, long and arduous education, development of complex and demanding skills."[19]

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[18] Visher, *Scientists Starred*, pp. 109–110.

Among these agencies basically responsible for producing the nation's scientists, however, the most important to which we must look for the encouragement of scientific talent is the school. No other institution has the school's wealth of opportunity to instill in the young mind the values and importance of intellectual accomplishment in general and of scientific endeavor in particular. The school's stimulation of the pupil through good teaching, its encouragement of independent thinking and well-rounded growth, and its creation of an atmosphere of the common search for knowledge whether the subject be spelling, arithmetic, history, or home economics, are all important factors in leading students toward the scientific laboratory. At least to some extent these factors can be seen operating in the schools today. In any era the nation's schools are important because they serve the young during the great decision-making years of their lives, because they help form basic learning habits and attitudes toward knowledge, study, and the search for truth. But both elementary and secondary schools seem especially important to the encouragement of science today because of the increasing numbers attending them and because of the growing scope of their offerings.

To just what extent the nation's schools encourage scholarly endeavor is a matter of considerable current controversy.[20] Critics of our public schools have condemned them for the products they turn out, for the inadequate teaching that is said to exist, for the superficiality instilled in the student, and for catering to the mediocre pupil at the expense of the superior one. Various aspects of current educational philosophy have been scrutinized by critics who have attacked John Dewey's influence, bewailed the wide variety of new subjects taught in the classroom, and denounced new pedagogical methods, particularly if they cost taxpayers any money. The schools' defenders, on the other hand, have cited studies to show that today's pupils are better than yesterday's, are well informed, and can read and write much better than their predecessors 50 years ago. They point out, for instance, that four times as many classroom hours are now devoted to the three R's than was done a century ago. Champions of today's public schools argue that modern times demand modern methods, that all the needs of all the children must be met, that learning, to be effective, must be interesting and that their critics misinterpret John Dewey's philosophy, if indeed they have read him at all.

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[19] Henry (ed.), *Adolescence*, p. 212. It should be noted, however, that since the end of World War II Knapp and Greenbaum have observed an increased number of scientists recruited from the ranks of the wealthier classes. See Knapp and Greenbaum, *The Younger American Scholar*, p. 96.

[20] Among the many recent contributions to this controversy are Bestor, *Educational Wastelands;* Bush (Douglas), "Education for All is Education for None," *The New York Times Magazine*, Jan. 16, 1955, p. 13; Lynd, *Quackery in the Public Schools;* Melby, *American Education Under Fire;* Melby and Puner (eds.), *Freedom and Public Education;* Smith, *The Diminished Mind;* Woodring, *Let's Talk Sense About Our Schools;* and National Congress of Parents and Teachers, *101 Questions About Public Education.*

It is not our purpose to add fuel to this controversy. Many public and private schools at present are doing a difficult job very well and would do a better job if they had the means to do so. A number of schools are forced to offer curricula that are governed not by what they believe is educationally sound but by the limited means at hand. It is similarly not the fault of the schools that many of them are notoriously overcrowded and understaffed and that many face increasing numbers of pupils in the future. Only 7 per cent of the young people of high school age enrolled in high school in 1890; today, over three-fourths of this age group goes to high school. That the nation's elementary and high schools continue to provide a basic education to some 33,500,000 youngsters day in and day out on such small operating expenses is a tribute to their sturdiness and stamina. No industry turns out such valuable products on such low overhead as do the public and private schools.

But while our schools are good, they could be better. Faced with more customers than ever before, the current approach, while appropriate and quite adequate for most students, is not excellent enough for those of high ability. What the schools obviously need is not more attacks but support, chiefly greater financial support. It should be remembered that, basically, it is the public's responsibility if the nation's schools are not perfect. It is easy to criticize and condemn. But before castigating schools and science teachers for their failure to provide an adequate number of well-educated pupils enthused over the study of science, we should realize that if we want our schools to accomplish more, we must give them more support.[21] With this in mind, let us consider the ways pertinent to our inquiry in which schools might best improve if they had the necessary means to do so.

How is the public school handicapped in trying to identify and encourage its students of high ability? Unable to expand in staff or facilities as fast as its student body, the school has been swamped with too many children and has had to devote its major efforts to coping with sheer numbers. This has forced the school to adopt a system of education which was recently described as "an enormous, complicated machine for sorting and ticketing and routing children through life."[22] As classes have grown, bright youngsters have received increasingly less individual attention and budding geniuses have without doubt been overlooked and neglected. Large class size puts a premium on standardization, and in a standardized program the interests of those with distinguished ability suffer. These students can coast along without much exertion and may never realize how much they could really accomplish if sufficiently challenged.[23] Programs characterized by strong intellectual challenge, superior quality of instruction, and high standards can be potent stimulants to a scientific career while diluted curricula and uninspired teaching will often fail to develop potential scientists. Incidentally, this is of course as true for colleges as it is for secondary schools.

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[21] For further comment on this question see Stewart, "The Trouble with Science Courses," *The Scientific Monthly*, vol. 79, no. 3 (Sept., 1954), p. 168; Educational Policies Commission, *Education of the Gifted*, p. 29; Martin, *The Teaching of General Biology in the Public High Schools of the United States*, United States Department of Health, Education, and Welfare, Office of Education, Bulletin 1952, No. 9, p. 37; Thornton, *Science and Social Change*, p. 111.

[22] Warner, *et al.*, *Who Shall Be Educated?*, p. 49.

Heavy increases in enrollment, coupled with teacher shortages, have led in some instances to setting the pace for the slowest learner, aiming the subject at the mediocre rather than the superior student. When long faced with situations in which they must follow this alternative, teachers and administrators tend eventually to regard the "norm" of their students as the "normal" and thus desirable level of performance. But as Sidney Pressey has observed of schools in which this happens, "Superior students could move toward an educational goal much more rapidly. For them rapid progress is normal."[24]

Furthermore, the necessity or near-necessity in some schools to promote all students regularly regardless of their performance, and the school's accompanying underemphasis on grades and other symbols of intellectual superiority, have also handicapped the able child. In a sense, it might be said that many schools seem no longer to base their philosophical orientation on intellectual attainments and academic scholarship. Secondary school educators point out that the schools were so oriented in 1870 because three-fourths of all secondary school students then went on to college. Today, they observe, with great increases in the proportion as well as the numbers of teen-age youth attending high school, three-fourths of all secondary school students do not go on to college. Schools have accordingly adapted their programs to what educators have felt best for the bulk of the students and have given more attention to such things as vocational training, social adjustment, and problem pupils than to the gifted child, who has been thrown more and more on his own resources. Just as the old public elementary and high schools had their deficiencies in a rigid curriculum based on little or no regard for individual differences, so, too, the modern school, faced with a far wider variety of student interests and problems and insufficient resources, has been forced to give less attention to the student of outstanding ability.[25]

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[23] Statistics on a survey of provisions available for superior students in 900 high schools will be found in National Education Association, "High School Methods with Superior Students," *National Education Association Research Bulletin*, vol. XIX, no. 4 (Sept., 1941), p. 170, 174. For a consideration of the arguments for and against current promotion policies and other aspects of public education see Lindquist (ed.), *Educational Measurement*, pp. 21–29.

[24] Pressey, "Time-Saving in Professional Training," *The American Psychologist*, vol. 1, no. 8 (Aug., 1946), p. 328.

It should not be overlooked, however, that neglect of the gifted child in the schools, though fairly common, is not universal. As long ago as 1930, four states—California, Oregon, Pennsylvania, and Wisconsin—had specific legislation authorizing special classes in the public schools for the mentally gifted. Two of these states provided additional financial aid to the schools for such classes.[26] Today, a number of schools provide for superior students by allowing them to carry unusually heavy programs or by arranging special classes, groups within classes, or curricula for them.

There are a variety of ways in which the great potentials for scientific encouragement in the schools might be realized through special arrangements for the gifted or unusually able child. Paul Brandwein describes some of them in his volume, *The Gifted Student as Future Scientist.* The early admission to college experiment, the Portland, Oregon, project enriching the curriculum to develop outstanding abilities, and the program of admission to college with advanced standing are some of the better-known recent attempts to provide richer educational opportunities for the gifted. In addition to special programs at the secondary school level it would be well to note that even at the elementary school level scientific aptitudes and interests can be encouraged.[27]

Much has been written about the advantage of acceleration in school for the superior student. Although systematic evaluation has not been completed, the apparent success of the early admission to college experiment sponsored by the Fund for the Advancement of Education has underscored the evident waste involved in the step-by-step process of yearly promotions through the 12 years of elementary and secondary schooling. Lewis Terman, Leta Hollingworth, and others have reported on the beneficial effects of acceleration on the brilliant students they have studied. Acceleration in the educational process is not new by any means. As early as 1868 William T. Harris introduced a rapid promotion arrangement in the public schools of St. Louis. Later that century the Cambridge "double-track plan" enabled the superior student to do the work of eight years' schooling in six. The many advantages of acceleration include its efficiency, its decrease in the waste of time, its enhancement of the child's motivation, and its earlier completion of formalized training, enabling a gifted person to reach the productive stage of life more quickly.[28]

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[25] For discussion of this point, see Spaulding, "Scholarship in the Secondary School," Princeton Bicentennial Conference on the Future of Nuclear Science, *Physical Science and Human Values, a Symposium,* p. 3.

[26] Bentley, *Superior Children,* p. xx.

[27] For a consideration of science instruction in the elementary school see Martens, *Curriculum Adjustments for Gifted Children,* p. 54; Association for Childhood Education, *Science and The Young Child,* p. 10; Blough and Blackwood, *Science Teaching in Rural and Small Towns* and *Teaching Elementary Science;* Blough and Huggett, *Elementary School Science and How to Teach It.* For one recent proposal to improve the mathematical preparation of superior secondary school students, see Walker, "The Training of Physical Scientists in the United States," *The Journal of Higher Education,* vol. XXV, no. 8 (Nov. 1954), pp. 417–421.

In Terman's studies of gifted children he reported that the accelerated did better in high school than those who proceeded at the normal pace, more of them graduated from college with honors, and more of them went on to do graduate work. Furthermore, he found that there was little difference in social adjustment between the two groups. It was his opinion that children with IQ's of 135 or higher should be so promoted that they could enter college by 17 at the latest, and that a majority in this group would gain much if they entered at 16.[29] Leta Hollingworth has declared, "In the ordinary elementary school situation children of 140 IQ waste half of their time. Those above 170 IQ waste practically all of their time."[30] Morris Meister has also pointed out that there is probably just as much danger of social and emotional upset from retardation as from acceleration. The quality and efficiency of learning is much more important, in his opinion, than the length of time which the student spends in school.[31]

Examples of successful acceleration in the past are strong arguments in its favor. Emerson was 14 when he entered Harvard; Longfellow, 15 when Bowdoin admitted him; Hamilton was of tender age when he started studying at Columbia; Charles Evans Hughes was 19 when he graduated from Brown.

On the other hand, there are problems of social and emotional adjustment which acceleration seems to intensify for some individuals. Skipping grades may tend to encourage one-sided development, may harm physical health, and may leave gaps in the child's academic preparation. Although the social costs of acceleration may be minimized through careful control it is also apparent that holding the high ability students back to a normal year-by-year progression does not impede school achievement as much as some educators believe.[32] Acceleration becomes a calculated risk, one worth taking for the real genius who should be encouraged to go just as fast as he wants, and one that might be allowed for the top quarter in ability in order to gain one or possibly two years at the most prior to admission to college. We really do not know as yet how much more we gain by acceleration than we lose. As a factor in encouraging the production of scientists, our estimate is that school acceleration on a more extensive basis would increase the scientific supply picture by about several thousand man-years but the absence of acceleration probably does not, by itself, deter anyone from studying for a career in science.

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[28] Additional discussion of acceleration will be found in Carroll, *Genius in the Making*, p. 219; Hollingworth, *Children Above 180 I.Q.*, p. 314; Henry (ed.), *The Education of Exceptional Children*, p. 260; Terman and Oden, *The Gifted Child Grows Up*, p. 264; Educational Policies Commisson, *Education of the Gifted*, p. 50. For a listing of some of the studies dealing with scholastic performance of accelerated students see Garrett, "A Review and Interpretation of Investigation of Factors Related to Scholastic Success in Colleges of Arts and Science and Teacher's Colleges." *The Journal of Experimental Education*, vol. XVIII, no. 2 (Dec., 1949), pp. 117 ff.

[29] Terman and Oden, *op. cit.*, p. 281.

[30] Hollingworth, *op. cit.*, p. 299.

[31] Meister, *Enriched Acceleration of High-Ability Youth in School or in College?* p. 2. See also Witty (ed.), *The Gifted Child*, pp. 42–43; Learned and Wood, *The Student and His Knowledge*, p. 321.

[32] See, for instance, Garrison, *The Psychology of Exceptional Children*, p. 254; Terman and Oden, *op. cit.*, p. 280.

The use of ability groupings, special classes for the gifted, special departments and schools, multiple-track plans, and various forms of enrichment in the curriculum are other devices which serve to stimulate students of high ability. It is noteworthy that as early as 1886 ability grouping was used in the public schools of Elizabeth, New Jersey. At the present time very little is known about which of the different procedures is most effective in educating talented youngsters. In the various approaches taken toward special programs for the gifted, flexibility, imagination, and common sense seem to be stressed most frequently by educators. It has been pointed out, for instance, that special courses for the gifted should be fitted in without depriving them of the many advantages which come from common experience in a heterogeneous class. Furthermore, it is apparent that the success of special classes depends to a great degree on excellent teaching.[33]

At present there are few such programs for the gifted child. In 1948 it was reported that about 20,000 pupils were enrolled in special schools and classes for the mentally gifted while 87,000 were enrolled in special schools and classes for the mentally deficient. In a survey made in 1948, only 2 per cent of the superintendents of schools in 288 cities and counties reported that their schools had special classes for the gifted. Nine per cent had some kind of enrichment program.[34] California apparently is more active in this area than other states. A recent study of California public schools revealed about one-quarter of the schools with an enrollment over 500 provided special classes for superior students.[35] Today apparently only about 5 per cent of the mentally gifted are being given any special formal attention.[36] There is clearly need for more extensive special programs and special schools to provide superior education for our superior children.

In this respect, Morris Meister has pointed out the need for a variety of approaches to the problem of more extensive attention to the superior student. Of the most able 600,000 children in the United States, he has estimated, about one-third live in large cities where the population can afford several different high school structures. Another sixth of the gifted children live in areas where some consolidation of school facilities is possible, thus affording a flexibility in the schooling offered. But half of the top 600,000 schoolchildren live in small communities where only one school is available to them and consequently there is little variation possible in the curriculum they must follow. "Even with twice the amount of money now available for high school support," he has asserted, "no school unit of less than 500 students can offer the enriched and flexible program required by the varying interests and abilities of its students, not to mention the enrichment called for to meet the needs of gifted boys and girls."[37]

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[33] For a more extended discussion of this matter see Passow *et al.*, *Planning for Talented Youth;* Brown and Johnson, *Education for the Talented in Mathematics and Science*, p. 7; Carroll, *Genius in the Making*, p. 262; Educational Policies Commission, *op. cit.*, pp. 52–67; Garrison, *op. cit.*, p. 260; Hollingworth, *op. cit.*, pp. 241–315; Witty (ed.), *op. cit.*, p. 67; and Klinge, "Working with Gifted Science Students in Secondary Schools," *Science Education*, vol. 38 (April, 1954), pp. 219–220.

[34] Witty (ed.), *op. cit.*, p. 194, 206.

[35] Brown, *op. cit.*, p. 7.

[36] Garrison, *op. cit.*, p. 250; United States Department of Commerce, Bureau of the Census, *Statistical Abstract of the United States, 1954*, p. 140.

Because of the financial costs involved and because programs for gifted students should be accompanied by programs for other groups as well, co-operation and careful planning among communities are necessary. More effective high school science teaching and more widespread programs for the superior students can be achieved partly through a joining of forces among the schools of a community and among several communities in a region. A greater division of labor might be considered so that schools would offer different subjects or special classes for those in a given area whose ability warranted it. A pooling of resources, equipment, teachers, and texts might be tried.

There is an obstacle to be overcome, of course, in the public opposition to special treatment for the intellectually superior. The Jeffersonian emphasis on giftedness runs counter to the more popular Jacksonian stress on equality. Some people oppose programs for the gifted because they believe that they produce an intellectual elite, an aristocracy of self-centered, bookish individuals with little or no contact with the common man or with everyday practicalities. However, there is little evidence that this is the case. Enrichment and acceleration programs need not be incompatible with the principle of equality of educational opportunity. Eric Rogers has presented a different reason for advocating special instruction for intellectually superior youngsters:

> "If special teaching for the ablest young scientist seems undemocratic, we may turn an anxious glance at athletics. Perhaps it is equally undemocratic to give special coaching to the football squad. Let us suggest that every senior in the school take his place in the football team in rotation, every pupil take a turn in the baseball team. Now return from such unhappy thoughts to the scientists

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[37] Meister in Witty (ed.), *op. cit.*, pp. 211–212.

and give the young scientist the coaching he deserves, for his good, the good of science, and the good of mankind."[38]

Because of our dire shortage of persons with specialized ability and because of the early achievement levels in human beings, we must get away from the notion that there is something inherently bad or undemocratic about acceleration or the devising of special programs for the high ability student. We have fast and slow lanes in our highways. We accept the need for local and express trains. We recognize the existence of wide variations in physical strength and expect a strong man to carry more, leap higher, and run faster than a weak one. To force the rapid learner to mark time or to deprive the brilliant student of additional intellectual challenge is a waste of a natural resource, human talent. Once this has been wasted, it can never be retrieved.

Besides acceleration and other provisions for the gifted, there are several additional aspects of the schools that have an important bearing on the production of scientists. One such aspect that apparently augurs well is their increasing "holding power." In Indianapolis, for instance, the public high school drop-out rate decreased from 55 per cent in 1946 to 42 per cent in 1953, and for 1956 may prove to be as low as 39 per cent. In the entire nation, a record 62.5 per cent of those who had entered public high school four years earlier graduated in 1951.[39] It has been estimated that by 1955 the nation-wide graduation rate among all high school entrants had exceeded 70 per cent. The larger the number of high school graduates, the larger the nation's reservoir of potential scientists and engineers is likely to be. This will not be the case, of course, if increased holding power means that only those of low ability are being retained in school, but it will be true to the degree that increased holding power reflects an improved college preparatory program or growing student interest in academic work.

Another aspect of the schools obviously important in producing scientists is their course offerings in general and their science offerings in particular. The increasingly wide variety of nonacademic courses generally available for graduation credit that has stemmed from mass high school attendance bears directly on the recruitment of students for scientific careers. The many course options now available to students serve frequently to deter them from taking the high school mathematics, physics, and chemistry essential to a college science major. The new practical, interesting, and frequently helpful electives available to the high school students should not be disparaged in themselves. But it is unfortunate that young persons are most often not given sufficient information about their capabilities or guidance in selecting careers before they elect courses in driving an automobile, stenography, or consumer economics instead of the "harder" ones in trigonometry or physics. It may be fine to have high school students exercising freedom of choice in planning their programs, but their choices will not be truly free if the school cannot insure that they will be based on fairly full information. We should not expect the schools to curb the education of the many but we should help the schools to enhance the education of the few who can make a significant contribution to society if their intellectual capacities are fully developed.

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[38] Rogers, "A Letter to High School Science Teachers from a College Science Teacher," *Bulletin of the National Association of Secondary-School Principals*, vol. 37, no. 191 (Jan., 1953), p. 46.

[39] Gaumnitz, *High-School Retention by States*, United States Department of Health, Education, and Welfare, Office of Education, Circular No. 398, p. 4.

Schools which do emphasize intellectual accomplishment, at the same time that they give attention to matters of personal and social development, can do much to stimulate the student with a budding interest in science. It seems particularly vital that the type of child possessing the characteristics Riesman calls "inner-directed" receive encouragement from his teachers, that he be made to know that his intellectual accomplishments are important, that his skills have as much value as his social graces.

Good science courses in particular are obviously essential in developing future scientists. Indeed, as Paul Brandwein has indicated in *The Gifted Student as Future Scientist,* schools that have outstanding science programs also turn out a higher proportion of college students as well as candidates for various academic awards than do schools with weak science offerings. Considering its importance, let us briefly review the history of science instruction in the nation's secondary schools and then examine its present status.

From the establishment of the Philadelphia Academy by Benjamin Franklin in 1751 down to 1880, science courses in American schools tended to serve religious and utilitarian ends and to be predominantly descriptive in content. From 1880 to 1910 the religious objectives of earlier years gave way and science courses emphasized drill, factual information, and the training of the mind. It was in this period that laboratory instruction in science made great strides. A third era from 1910 to 1940 was marked by a reaction against the earlier stress on memorization and mental discipline and a revived emphasis on the utilitarian aspects of science. One of the major objectives of this period was to make science seem more vital to the young. We now seem to be in a fourth period, possibly one of transition, in which new vistas for science teaching are being opened as a result of recent advances in both technology and educational psychology and in which there appears to be a relative neglect of the traditional science courses on the part of both students and school administrators.

In some schools science teaching has become incorporated into instruction in health, physical education, industrial arts, vocational, and other courses. It is a period in which science instruction has a dual purpose: to provide all future citizens with some knowledge of science, and to give a basic foundation in the subject to enough future scientists, engineers, and technicians to meet the growing demand.[40]

Corresponding trends in enrollments in natural science courses from the period marked by the rise of laboratory instruction down to 1948 are given in Table 11, which lists the percentage of pupils enrolled in particular secondary school science courses at irregular intervals since 1890. The rapid rise in the popularity of biology and the steady decline in the percentage electing physics are particularly noteworthy. Not shown in the table but also noteworthy is the fact that 82 per cent of all pupils in the regular four high school grades in 1910 were enrolled in science courses, while the corresponding figure in 1948 was 54 per cent.

TABLE 11

TRENDS IN SCIENCE COURSE ENROLLMENTS, 1890-1948[a]

Year	*Ninth grade general science*	*Biology*	*Chemistry*	*Physics*
1890			10.10%	22.21%
1895			9.15	22.77
1900			7.72	19.04
1905			6.76	15.66
1910			6.89	14.61
1915		6.90%	7.38	14.23
1922	18.27%	8.78	7.40	8.93
1928	17.50	13.58	7.07	6.85
1934	17.75	14.60	7.56	6.27
1947	19.32	19.51	8.62	5.49
1948	20.8	18.4	7.6	5.4

[a] Percentage of all public high school students enrolled in science courses from 1890 to 1948. Figures for 1890-1947 taken from Johnson, *The Teaching of Science in Public High Schools*, United States Department of Health, Education, and Welfare, Office of Education, Bulletin 1950, No. 9, p. 6; figures for 1948 taken from Johnson, "Occurrence of Science Courses in American High Schools," *Bulletin of the National Association of Secondary-School Principals*, vol. 37, no. 191 (Jan., 1953), p. 24.

If the status of science instruction today is considered, science programs are apparently stronger in senior than in junior high schools; larger high schools have better offerings than do those enrolling fewer than 200 pupils—

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[40] Although now somewhat old, a brief account of science instruction through the years will be found in Progressive Education Association, Commission on Secondary School Curriculum, *Science in General Education*, chapter I. See also *Bulletin of the National Association of Secondary-School Principals*, (*Science in Secondary Schools Today*), vol. 37, no. 191, (Jan., 1953).

TABLE 12

SCIENCE COURSE OFFERINGS AND ENROLLMENTS, 1949[a]

Courses	*Schools offering courses*[b]	*Course enrollment*[c]
7th grade general science	71.6%	61.6%
8th grade general science	96.3	78.4
9th grade general science	77.4	66.2
Biology	85.2	74.9
Chemistry	49.4	39.4
Physics	47.8	28.4

[a] Figures taken from Johnson, *The Teaching of Science in Public High Schools*, p. 5.

[b] Percentages of the 715 junior or senior public high schools in Johnson's sample which offer the courses listed.

[c] The percentages for junior high school represent the proportion of students in each grade enrolled in that grade's general science course; the percentages for biology, chemistry, and physics represent the proportion of students enrolled in the 10th, 11th, and 12th grades respectively.

which constitute half of all high schools in the nation. Physics and chemistry are taught less frequently in the smaller schools. With respect to chemistry, Philip Johnson discovered in a 1949 survey of a sample of 715 public high schools that, in the schools enrolling less than 100 students, the number of those taking chemistry was equivalent to less than 25 per cent of the eleventh-grade pupils in these small schools.[41] About one-third of almost 10,000 high schools surveyed by the American Chemical Society in 1955 offered no chemistry courses.[42] High schools frequently require only two semesters of science for graduation, although in some schools four or more semesters are required. As has been remarked, science is also taught in health, vocational, and other courses.[43]

Some indication of the extent of current offerings and enrollments in various high school courses in the natural sciences is given in Table 12, which is based on the 1949 sample of schools studied by Philip Johnson. These figures of course do not reflect the wide variations found in the quality of offerings. One index of quality is laboratory and demonstration facilities. In some schools, up-to-date equipment for informative experiments is available; in others the science room is no different in appearance from any other classroom. In the sample of schools on which Table 12 is based, four-fifths of those offering seventh and eighth-grade general science could apparently provide for only classroom recitation. One-fourth of the schools in the sample offering chemistry could not give laboratory instruction in it.[44] Bernard Jaffe has recently reported that a "surprising" number of high school chemistry students do not perform experiments in their courses.[45]

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[41] Johnson, *The Teaching of Science in Public High Schools*, p. 5.

[42] *The New York Times*, March 29, 1955.

[43] See *Bulletin of the National Association of Secondary-School Principals*, vol. 37, no. 191 (Jan., 1953), p. 27.

[44] Johnson, *op. cit.*, pp. 34–36.

In another important area of science instruction, Table 13 similarly illustrates the trends since 1890 in the enrollments of mathematics courses in public secondary schools. Recently Kenneth Brown made a survey of a sample of public high schools the results of which indicated, as the table also does, that the percentage of pupils enrolled in algebra and geometry courses has been steadily declining while the percentage enrolled in trigonometry seems to remain about the same. Algebra, a subject basic to many fields of knowledge and essential to preparation for a scholarly career, may be decreasing in popularity among students and it is not universally required by secondary schools as was formerly the case. Slightly more than half of the schools in Brown's study required algebra of their college-preparatory students for graduation. Only about one-third of these schools required the subject of all students. In the case of plane geometry, approximately 42 per cent of the high schools require the course of their college preparatory students. Enrollment in trigonometry in 1952 amounted to about 5 per cent of the number enrolled in the twelfth grade. Only about 4 per cent of the regular and senior high schools require plane trigonometry of their college-preparatory pupils.[46]

TABLE 13

TRENDS IN MATHEMATICS COURSE ENROLLMENTS, 1890–1953[a]

Year	*Algebra*		*Geometry*		*Trigonometry*	
1890	92,150[b]	45.4%[c]	43,294[b]	21.3%[c]	....	....
1900	292,287	56.3	142,235	27.4	9,915[b]	1.9%[c]
1910	420,207	56.9	228,170	30.9	13,812	1.9
1915	569,215	48.8	309,383	26.5	17,220	1.5
1922	865,515	40.2	488,825	22.7	32,930	1.5
1928	1,020,323	35.2	573,668	19.8	36,855	1.3
1934	1,367,210	30.4	767,171	17.1	59,858	1.3
1949	1,448,966	26.8	693,280	12.8	108,551	2.0
1953	1,475,900	24.6	659,300	11.6	107,000	1.9

[a] Sources: figures for 1890–1949 from United States Department of Health, Education, and Welfare, Office of Education, *Biennial Survey of Education in the United States, 1948–50,* chapter 5, p. 107; figures for 1953 from Brown, "Mathematics a Key to Manpower," *School Life,* vol. 36 (Nov., 1953), p. 26.

[b] Number of public secondary school students enrolled.

[c] Percentage of all public secondary school students enrolled.

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[45] *Bulletin of the National Association of Secondary-School Principals,* vol. 37, no. 191 (Jan., 1953), p. 72. For a recent work on science facilities see Richardson (ed.), *School Facilities for Science Instruction.*

[46] Brown, *Mathematics in Public High Schools,* United States Department of Heath, Education, and Welfare, Office of Education, Bulletin 1953, no. 5. See also Brown, "Mathematics a Key to Manpower," *School Life,* vol. 36 (Nov., 1953), p. 26.

Considerable variation in studying mathematics occurs from region to region. It has been estimated, for instance, that one-quarter of the high schools in Arkansas teach no mathematics. In New England, the Middle Atlantic states, the Mountain states, and the Pacific region, mathematics courses are taken by a greater proportion of the student body than in the other sections of the nation. While almost half of the secondary schools in the New England and Pacific regions require plane geometry of their college-preparatory students, about 20 per cent of those in the West North Central region have such a requirement.

Brown's study reveals other interesting points. Apparently four times as many boys take trigonometry and solid geometry as girls. In the case of geometry, approximately one-fifth of the boys found their experiences in the course unsatisfactory and did not continue its study.

The loss of capable students from high school to college is intensified by the fact that many with good ability are lost to the scientific professions through their failure to take basic mathematics courses in high school and through the school's failure to make instruction in these courses as stimulating and as meaningful as possible. As part of the Steelman Report some years ago a thorough study of mathematics instruction was undertaken. One of the conclusions is disheartening: "The typical first-year algebra course does not nurture scientific aptitudes and certainly is not realistic as regards problem material, to say nothing of an emphasis on science."[47] Kenneth Brown reflected the view of many when he declared that if our supply of specialized persons in the labor force were to be increased, the enrollments in secondary school and college mathematics courses of capable pupils must expand.[48] James B. Conant came to a similar conclusion when he observed, "Mathematics, of course, is of the first importance, and probably more talent is lost to the sciences pure and applied . . . by the inadequacies of our schools in this field than in any other."[49]

These figures may suggest several conclusions concerning the effect of secondary school course offerings on the future production of scientists and engineers. High school mathematics and science instruction is one of the most important potential forces for the encouragement of scientific careers.[50] At the present time, however, not enough students are being stimulated by this instruction to pursue the study of science further. Boys and girls frequently have a strong interest in scientific areas as they begin their school years.

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[47] Steelman, *Science and Public Policy*, vol. IV, p. 80.

[48] Brown, "Mathematics a Key to Manpower," *School Life*, vol. 36 (Nov., 1953), p. 39.

[49] Conant, *Education in a Divided World*, pp. 150–151.

[50] See Cairns, "Mathematics and the Educational Octopus," *Scientific Monthly*, vol. 76 (April, 1953), p. 239.

Gradually, through elementary and high school, some of that initial enthusiasm for rocks, animals, stars, and numbers, that enjoyment of tinkering, measuring, and experimenting, is rubbed off. Sometimes the early interest in science is replaced by a new interest. Sometimes because of the nature of the instruction, a fascination for things scientific is replaced by aversion. Early interest in science is not a good indication of future success in a scientific career but lack of interest, precipitated by classroom experiences, takes a young person out of the group from which will come our future scientists and engineers.

In any event, it seems advisable for more boys and girls to study mathematics and science and to start the study of these subjects earlier in the elementary school than they are now doing. Indeed, increasing the amount of mathematics and science studied by all able students in school would be beneficial to them regardless of their eventual careers. The sixth and seventh grades may well be the crucial point at which to check the loss of high ability persons to scientific careers. Quantitatively, the nation's secondary schools are now graduating about 50,000 students a year well oriented toward science. It is George Harrison's conclusion that they should be producing twice that number.[51]

The importance of individual encouragement cannot be overemphasized. That is why laboratory experience in science courses is so crucial. When it is well conceived, it can be instrumental in giving a talented youngster self-confidence and the realization that he has the capabilities to go forward in some line of experimental work. When laboratory experience is lacking or when its relation to the course is perfunctory or uninspired, even the brightest student is not likely to get the encouragement he needs to maintain a lively interest in some field of science.[52]

One aspect of the contemporary school scene that has a particularly crucial bearing on the nation's future supply of scientists and engineers is of course the teacher. Not only is the quality of teaching a decisive element insofar as learning any subject is concerned; the supply of teachers determines in many cases whether or not courses in the subject can even be offered. When we examine the shortage of science teachers, as we shall below, we will be able to understand something of the extent to which schools have been forced to curtail their course offerings in the sciences over recent years because of a lack of teachers.

Moreover, there are valid grounds for declaring that the teacher can be the most effective single individual in stimulating a child toward a scholarly career.

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[51] Harrison, "The Role of the Secondary School in the Teaching of Science," *Physics Today*, vol. 5, no. 6 (June, 1952), p. 12. For an examination of early interests in science see Zim, *Science Interests and Activities of Adolescents*. See also Brandwein, *The Gifted Student as Future Scientist*.

[52] For additional consideration of this point, see Cohen and Watson (eds.), *General Education in Science*, p. 73.

Many outstanding individuals in diverse walks of life have paid tribute to the influence excellent teachers have exerted on their characters and careers. In their study, *Origins of American Scientists,* Knapp and Goodrich have indicated that the popularity and effectiveness of a science faculty has a direct influence on the students' interest in science.[53] Statistics reported by Brandwein, Visher, and others substantiate the conclusion that superior high school teachers are very influential in shaping career decisions. Some measure of a teacher's effectiveness can be seen in the results of contests such as the Science Achievement Awards where excellence in instruction is revealed by excellence in the student's work. In the 1953 awards, 42 teacher sponsors had more than one winner in this competition, 25 had three or more winners, and 6 teacher sponsors had five or more winners.[54] Excellent teaching can be particularly effective at the high school level, for the secondary school pupil responds readily to stimulation, finds inspiration in a strong personality, and welcomes the type of leadership that dynamic teaching provides.

Yet, on this crucial front where the personal effectiveness of stimulating instruction is known to pay off, our nation is losing ground. The national shortage of teachers is enormous. In the class graduating from college in 1954 there were only 50,000 possible candidates for high school teaching and 35,000 possible candidates for elementary school teaching—in all, some 50,000 or 60,000 short of the estimated number needed that year. To make matters still worse, only an estimated 77 per cent of the college graduates prepared for elementary school teaching and only an estimated 53 per cent of those qualified for high school teaching currently take teaching positions.[55] We need between 7,000 and 10,000 new science teachers each year. The eligible number now graduating yearly is about half that figure. Recently, a study in Minnesota revealed that only 41 per cent of those who were potential science teachers were employed in teaching science a year after their graduation.[56] In 1954, it is estimated, America's colleges turned out a little more than 200 persons qualified to teach high school physics and only 100 of these took jobs in the teaching profession. In a study of 200,000 students in two dozen outstanding colleges, only 600 were found qualified for a teaching certificate in science and mathematics, and many of these accepted attractive positions in industry at salaries far higher than those paid secondary school teachers.[57] During the last five years there has been a 56 per cent decrease in the number of teachers certified to teach science in secondary school; in physics, the decrease has been 75 per cent. According to one estimate, in the fall of 1954 over 100,000 high school students were enrolled in mathematics and science classes that were taught by inadequately trained teachers.[58]

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[53] Knapp and Goodrich, *Origins of American Scientists*, p. 296. For an excellent discussion of the importance of good college teaching see Severinghaus (Aura E.); Carman (Harry S.); and Cadbury (William E.), *Preparation for Medical Education in the Liberal Arts College* (New York: McGraw-Hill Book Co., Inc., 1953), pp. 189–208.

[54] Chase, "1953 Winners of Science Achievement Awards for Students," *The Science Teacher*, vol. XX, no. 4 (Sept., 1953), p. 193.

[55] Maul, "The Changing Nature of Our Teacher Supply," *School and Society*, vol. LXXX, no 2,043 (Oct. 2, 1954), pp. 98–99.

[56] Watson, "Crisis in Science Teaching," *Scientific American*, vol. 190, no. 2 (Feb., 1954), p. 28.

Inadequacies in their own training, the general shortage of teachers, and the problems of providing comprehensive science instruction in particular schools seem to be serious handicaps to the work of the too few men and women who are teaching science courses. Science teachers have frequently been hired by schools because of their additional qualifications in some non-science field. In the smaller high schools, about two-thirds of those teaching science also teach other subjects as well. Of the estimated 67,000 public high school teachers of the natural sciences in the nation, only about half teach science subjects full-time.[59] In the 715 schools surveyed by Philip Johnson, the proportion was less than half; 827 taught science full-time while 1,011 taught science part-time, giving other subjects as well. Johnson also reported, incidentally, that 60 per cent of the science teachers in his survey were men.[60] In a study of 1,171 secondary schools made in 1952 by Kenneth Brown, it was estimated that of the 65,000 mathematics teachers in the nation's public high schools, only about 29,000 were teaching the subject full-time.[61] In Illinois about 60 per cent of the biology teachers and practically all of the chemistry and physics teachers also give other subjects. Fletcher Watson has reported that in New York, Minnesota, and Utah half of all science teachers have three or more courses in different science subjects to prepare each day and about 40 per cent of them have no permanently assigned classroom but must move their teaching materials from room to room.[62] In North Carolina, science teachers spend about 40 per cent of their time giving courses in other fields, and it has been estimated that some 10,000 North Carolina high school students are currently taught science by teachers who have had no certified preparation in science.[63] Throughout the nation, less than 60 per cent of those who are certified to teach in biology majored in the subject in preparing for certification, and over 10 per cent of the nation's certified biology teachers neither majored nor minored in a biological science.[64]

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[57] Harrison, "The Role of the Secondary School in the Teaching of Science," *Physics Today*, vol. V, no. 6 (June, 1952), p. 14.

[58] Taylor, *Effect of Defense Program on Employment Situation in Elementary and Secondary School Teaching*, United States Department of Labor, Bureau of Labor Statistics, Supplement to Bulletin 972, p. 3, 5.

[59] *Bulletin of the National Association of Secondary-School Principals*, vol. 37, no. 191 (Jan., 1953), p. 35, 36, 75, 77.

[60] Johnson, *op. cit.*, p. 24.

[61] Brown, *Mathematics in Public High Schools*, United States Department of Health, Education, and Welfare, Office of Education, Bulletin 1953, no. 5, p. 38.

[62] Watson, *op. cit.*, p. 28.

[63] Shannon, "Science Teaching—Present Status and Future Progress," *North Carolina Education*, vol. XXII, no. 9 (May, 1954), pp. 16–18, 51–53.

To a considerable degree, our huge teacher shortage and its damaging consequences can be traced directly to low salaries. In 1955 the starting salary for a teacher in the New York City schools, which have one of the highest salary scales in the country, was $3,450 or $3,650 with a master's degree. The average national salary for all teachers in 1955 was only $3,400, while the average salary that 1955 college graduates could expect to be offered immediately was $4,092.[65] With such meager financial attractions, those with superior ability are being drained away from the profession. The results a decade from now in the production of scientists and other scholars may well be disastrous. It is no wonder that Fletcher Watson has declared, "For want of a few thousand competent new science teachers each year science instruction in our schools must either be curtailed or become such a caricature of teaching as to bore or repel promising students."[66] Our teacher shortage used to be called a crisis. It is now a calamity.

Low salary is but one indication of the unthinking public attitude toward the teaching profession. The relatively poor prestige enjoyed by the teacher, his inadequate working conditions, and the abuse he is obliged to take are other evidences of public indifference to his potential worth. Apparently this is a tradition. In 1837 a British visitor wrote:

> "But with what zeal can a man devote himself to a profession at once laborious and difficult, in which the greatest success is incapable of procuring distinction?—which exposes him to unmerited contempt and reproach? And why should a pettifogging lawyer or a quack, consider himself better than a honest and successful instructor?"[67]

Things have improved somewhat in 100 years but at the present time increases in teachers' salaries have not risen as fast as factory wages or the cost of living. Perhaps as long as public school salaries are tied to real estate taxes, it will be impossible to award meritorious teaching and recognize excellence in the classroom the way it deserves to be recognized. But if there is mediocrity in our schools, if the teaching is dull and uninspired, if there is a 50-year lag in the introduction of new materials and techniques, if pupils are being bored instead of stimulated, we have partly ourselves to blame for failing to give teachers the pay and status they deserve. Several thousand science teachers will leave the profession this year to take non-teaching positions. They take with them a potential ability which, if it were kept in the classroom, could stimulate greatly the production of scientists and engineers.

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[64] Martin, *The Teaching of General Biology in the Public High Schools of the United States*, United States Department of Health, Education, and Welfare, Office of Education, Bulletin 1952, no. 9, p. 18.

[65] *The New York Times*, Jan. 2 and Jan. 22, 1955.

[66] Watson *et al.*, *Critical Years Ahead in Science Teaching*, p. 28. See also National Manpower Council, *Proceedings of a Conference on the Utilization of Scientific and Professional Manpower*, p. 139n., 154; Quattlebaum, *Federal Aid to Elementary and Secondary Education*, p. 25.

[67] Grund (Francis Joseph), *The Americans in Their Moral, Social, and Political Relations* (Boston: Marsh, Capen, Lyon, 1837), pp. 125–128.

A word might be said about the advantages in attracting more women to science teaching. Women who are college graduates and whose children are grown should constitute an excellent source of potential science teachers. The nature of the work, the shorter hours away from home, and employment opportunities that exist regardless of where the family is located should make science teaching more attractive to scientifically-minded women than some other types of scientific work. Short-term courses, some of which have already been instituted, to familarize women interested in teaching with new developments in their field and in education should be well worth the effort.

The school guidance program is another aspect of the schools that bears significantly on the production of scientists and engineers. The important role that guidance can play in helping the student make a satisfactory career in school is gradually being recognized by educators and the public alike. Many studies have underscored the importance of good academic, vocational, and personal counseling at all levels of the educational ladder. Recently an experiment was conducted among Massachusetts high school students of equal intelligence, half of whom were given guidance and half of whom were unguided. Twenty-seven per cent of the guided group became honor students while only 10 per cent of the unguided received such distinction in high school. After graduation, 53 per cent of the guided group and less than 36 per cent of the unguided group were admitted to institutions of higher learning.[68] Among the superior students whose records Terman examined, it was discovered that there were many cases in which a poor record in school was partly the result of insufficient guidance.[69] Especially in the area of selecting a vocation, adequate counseling in the school is essential. Donald Super has pointed out that vocational self-guidance frequently gives unsatisfactory results. Many persons go through school ignorant of their aptitudes and of current job opportunities.[70]

Yet despite its importance a sufficient amount of guidance is still not available. At the present time there are 18,000 to 20,000 persons doing counseling with junior and senior high schools, but less than half of them devote as much as half of their time to guidance work. Ten years ago there were only 8,000 guidance officers in the public schools. The latest study published by the National Manpower Council reported wide variations among states in the support given to the guidance program. The Council discovered that while California had over 1,200 counselors, New York, 700, and Massachusetts, 530, Alabama had 9 and North Dakota, 4.[71]

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[68] Rothney, *The High School Student*, p. 215.

[69] Terman and Oden, *The Gifted Child Grows Up*, p. 157.

[70] Super, *The Dynamics of Vocational Adjustment*, p. 151.

Although the picture has improved considerably in recent years, a decade ago less than 4,000 of the 24,300 public secondary schools had guidance officers.[72] When Bell made his study of youth in 1947, he discovered that only about one-third of those who were students reported having received guidance.[73] Of the schools included in the 5 per cent random sample of public high schools surveyed in the National Study of High School Students and Their Plans, over 50 per cent reported that there was no person on the staff who had an official appointment, even on a part-time basis, for counseling students. In the National Study, which was conducted for this report, 17 per cent of the high-scoring students checked "not at all" and only 26 per cent checked "quite a lot" when asked to what extent they had discussed going to college with their teachers or guidance counselors.

Frequently, the value of guidance to the high school or college student is overlooked by the educator and the man in the street. There is a lack of knowledge and understanding of what it means, of what it can accomplish. Able students and those planning to go to college, it is frequently felt, do not need any guidance. Despite the wealth of information available, apparently many schools lack adequate information on the specialized professions and on the importance of careful, continuous occupational planning. In addition, there appears to be in the philosophy of guidance a passivity that is sometimes not helpful to a student floundering for a career. In their study, *Occupational Choice,* Eli Ginzberg and his associates criticized this philosophy of "freedom" which when followed, they felt, fails to give the student the directed help he needs. They decried the "confusion caused by basing an educational system on what the student likes rather than on what he ought to learn . . . on the pleasant rather than on the necessary."[74]

On this point, a study was made some years ago of over 1,000 students in Ohio in grades seven to 12 to find out what the main confusions of pupils were regarding important factors in making occupational decisions. The seven desiderata given particular importance by the adolescents in the selecting of a job included "provision for retirement, chance for advancement, service to mankind, effect on health, chance to continue in the same position, freedom from political limitations, and possibility of spending time at home due to location of work." Generally speaking, the young people studied failed to recognize what factors were significant in determining success in the vocation they selected. The role of ability and preparation were overlooked. The desire for a position which demanded responsibility was given a low rating. On the whole, it was concluded that "the ordinary vocational guidance program apparently had not solved this problem. . . . From the seventh to the twelfth grade pupils showed little development in ability to recognize important factors of occupational choice. Education needs to insure such development."[75]

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[71] National Manpower Council, *A Policy for Skilled Manpower,* p. 269.
[72] *Occupations,* vol. 26, no. 7 (April, 1948).
[73] Bell, *Youth Tell Their Story,* p. 74.
[74] Ginzberg *et al., Occupational Choice,* p. 193.

Many of the same criticisms can be leveled at college guidance as well. The waste in manpower through insufficient or improper academic and vocational guidance at both the secondary and college level is too great. Academic and vocational counseling is a complex process requiring competent, trained persons interested in performing an important but often thankless job. To be effective, it must be continuous, directed, and based on adequate data about the child. Guidance in the lower grades should encourage the young student to include college-going in his plans. Advice given to pupils at the high school level should encourage them to postpone vocational commitments and avoid premature career decisions. As Terman has pointed out, "One should not be too early concerned about the gifted child's future vocation. Until his abilities and interests have had time to mature, the right vocational choice cannot be made, unless by chance."[76] In his authoritative study, *The Dynamics of Vocational Adjustment,* Super has declared that adolescence is essentially "an exploratory period, during which young people try themselves out in a variety of educational, vocational, and social activities."[77]

Effective guidance can play a particularly crucial role in providing superior girls with the information and help they need in order to include college and a career in their life plans. Vocational booklets outlining the advantages and attractions of scientific careers for women should be prepared and widely circulated. More important is the individual counseling by trained educators from elementary to graduate school who can encourage the girl with promising ability to continue to emphasize academic achievement and to prepare for some type of advanced study that would enable her to make optimum use of her intellectual faculties. It is particularly important that girls realize the need for their talents in scientific and engineering lines.

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[75] Edmiston and Starr, "Youth's Attitudes Toward Occupations," *Occupations,* vol. 26, no. 4 (Jan., 1948), p. 220.

[76] Terman in Witty (ed.), *The Gifted Child,* p. 44.

[77] Super, *op. cit.,* p. 136.

In addition, it would be well for the school to work more closely than it has been able to do with the parent in the guidance process. The suggestion has been made that school counselors might endeavor to place information about careers and colleges in the homes of their students whose parents are not likely to provide such information on their own. Classes for parents in guidance have also been recommended. In the final analysis, to be effective a school guidance program must have the whole-hearted support of the entire staff. It should also not be forgotten that the best counseling frequently goes on in the classroom. Next to his parents a stimulating, inspiring, sympathetic teacher is the best guide a child could ever have.[78]

In the final analysis, all these influences in the school, the community, and the home, all these special programs of professional societies, industrial corporations, and the government focus on the individual boy or girl. Why do some respond to these attractions and others not respond? Why are the deterrents so influential in some cases but in others can be disregarded? What is it in the individual that helps determine whether to strive for a scholarly career or settle for a more mundane job? Many call it "motivation."

The term, although convenient, is probably an unfortunate one when used to refer to the desire to go to college or to enter a particular scientific profession. Its use in experimental psychology has perhaps blurred its social connotations. It embraces an interest, a drive, an effort, and a goal. It includes those determinations which influence the choices one makes. It stands for the combination of emotions and rationalizations which influence an individual to initiate and continue thinking and acting in a particular direction for a particular purpose. It implies that some things are rewarding to some people to the point where they are willing to make sacrifices in order to reach their objective. Although much remains to be learned about motivation, there is a growing body of published material on it.[79]

As an encouragement to college or to scientific occupations, motivation in some individuals may be the determining factor. Where motivation is lacking, the likelihood that one will go to college is slight, even when ability, financial means, and school encouragement are strongly pushing in that direction. In some cases, motivation for college is so slight that even an offer of a large scholarship does not provide sufficient inducement to study beyond the high school level. Conversely, in some individuals, the motivation, drive, level of aspiration, ambition—call it what you will—is sufficiently strong to impel the youth to prepare himself for his career regardless of the obstacles in his way. In a memorandum prepared for this study, Robert J. Havighurst has suggested that high school students can be classified according to three categories, the well-motivated, the non-motivated and the mal-motivated. The well-motivated are strongly impelled toward college and a professional career; the non-motivated lack any desire for a higher education, while the mal-motivated have personality or character traits which would hinder or prevent satisfactory work in college.[80]

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[78] For additional discussion of this subject see Rothney, *The High School Student*, p. 151, 241; Berdie, *After High School–What?*, p. 80; National Manpower Council, *A Policy for Skilled Manpower*, pp. 5, 278–282.

[79] Recent discussions of motivation for college are found in Chase, *Motivation of Young Children*, p. 9; Maslow, *Motivation and Personality;* Bray, *Issues in the Study of Talent*, pp. 35–48; Conger, "Lack of Funds and Lack of Motivation as Barriers to College Attendance in New York State," pp. 84–92; McClelland, *The Achievement Motive*, pp. 7, 83, 319–327; Havighurst and Rodgers, "The Role of Motivation in Attendance at Post-High-School Educational Institutions" in Hollinshead, *Who Should Go To College*, pp. 135–184; Millett, *Financing Higher Education in the United States*, pp. 51–54; Henry (ed.), *Adolescence*, pp. 203–214; Gough, "Relationship of Socio-Economic Status to Personality Inventory and Achievement Test Scores," *Journal of Educational Psychology*, vol. 37 (Dec., 1946), pp. 527–540.

A particular problem exists insofar as motivation for college among girls is concerned. It has been said that to a certain extent society does not expect the same display of intellectual achievement in a girl as in a boy. There are tendencies at work which discourage some girls from preparing for college and for specialized careers. Frequently, for instance, there is a disinclination on the part of the individual girl and the public at large to picture science or engineering as an acceptable occupation for women. John Dale Russell has suggested a close connection between the "deep-seated mores of our society" and the failure of many girls to take advantage of the educational opportunities available to them.[81]

Apparently there are strong psychological reasons why more girls do not develop an interest in going to college. The adolescent feminine attitude toward achievement and competition is an important factor. Studies have been made that suggest that although girls respond more readily to the intellectual challenges of the classroom through high school, work harder for good grades, and tend to stay in school longer, when they reach adolescence they generally minimize academic achievement and gravitate toward a noncompetitive role. The Commission on the Education of Women, in reporting on the research of Jean Macfarlane and Lester Sontag, has stated that the intelligence quotients and grades of girls in high school become lower when they believe that their academic success hurts their popularity or femininity.[82] Similarly, as a result of his experiments, David McClelland has concluded that there are significant differences between men and women in their expectations in and reasons for achievement in our culture.[83]

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[80] See Havighurst, "The Individual: Personal Problems in Approaching Equality of Opportunity," American Council on Education, *Approaching Equality of Opportunity in Higher Education*, pp. 68–71. For an example of recent research on motivation for higher education see Gough, "Some Personality Differences between High Ability School Students Who Do, and Do Not, Go to College."

[81] See Russell, "New Factors Affecting Equality of Opportunity," American Council on Education, *Approaching Equality of Opportunity in Higher Education*, p. 30.

[82] Hottel in American Council on Education, *How Fare American Women?*, p. 25.

Motivation for study and scholarly careers in both boys and girls cannot be considered in a vacuum. It is reasonable to expect that the child's family and cultural environment serve to shape it to a considerable degree. Family approval and interest in scholarly attainments and rewards that make studies more worthwhile to the youngster can serve to nurture a motivation for college. Psychologists tell us that interest in going to college or in studying for a professional career are drives which are learned by the individual. Apparently, too, this learning process starts early in life. According to Tyler, it is possible to measure motivation as early as the fourth grade and to predict later success with reasonable accuracy since subsequent community and school environment does not seem to modify markedly the type of motivation developed in the first decade of a child's life.[84] If this is the case, then to attract the 100,000 unmotivated high ability high school graduates each year to scientific and other professional careers, we must start earlier than in their senior year in high school with programs that include more than an offer of a scholarship.

In order to utilize motivation as a force encouraging college-going and scientific careers, it is necessary to face the realities of adolescent methods in career decision. There are certain "choice points" in the lives of young people when motivation for college, if present, can exert decisive pressure. The first choice point occurs at the outset of schooling, in kindergarten and first grade. This is a time at which the attitude toward schooling reflected in the six-year-old's parents and friends helps shape his own approach toward learning to read, to write, and to do any more in his classroom experiences than play. The next identifiable choice point seems to occur at the end of the elementary school years when the youngster must decide whether to enter a college preparatory program in high school or follow a more "practical," vocational type of schooling. Although there is a continuous process of making choices going on, another important fork in the road occurs when the high school student elects how much mathematics and science to take. It is here where motivation for college can play a critical role and where decisions not to study science courses can take an adolescent out of the shrinking reservoir of potential scientists and engineers. A fourth important milestone occurs when, at the end of high school, the graduate must decide whether or not to go on to college. Additional choice points occur later for those who elect to continue their education but the biggest losses to the scientific profession have already occurred.

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[83] McClelland, *The Achievement Motive*, p. 330. See also Veroff, Wilcox, and Atkinson, "Achievement Motive in High School and College-Age Women," *Journal of Abnormal Psychology*, vol. 48, (Jan., 1953), p. 108.

[84] Tyler in Eells, *Intelligence and Cultural Differences; A Study of Cultural Learning and Problem-Solving*, pp. 41–42.

The process by which career decisions are made may explain why this loss tends to be so large. Although there is no single developed theory of vocational choice, the writings of Donald Super, Eli Ginzberg, and others throw light on the process of occupational decision-making. Apparently there are at least three elements in this process. First, there is the procedure by which choices are made through acquiring new goals, new interests. Second, there is the discarding approach by which objectives previously considered are dropped for one reason or another. Third, there is the compromise by which the young person cuts the cloth of his ambition to fit the cloak of his aptitude. Sometimes it is by way of a new discovery, sometimes through a process of eliminating careers, and sometimes through compromise that a fixed vocational choice is made. In addition, there appear to be distinct phases through which the adolescent moves, making decisions between the ages of six and 11 that have been called "fantasy choices," arriving at tentative occupational goals during adolescence in terms of interests, capacities, and later values, and during early adulthood narrowing down his choice more realistically as he gains knowledge and experience.[85]

Insofar as motivation for college is concerned, the following generalizations about the process of occupational choice seem pertinent. Picking a vocation appears to consist of a series of decisions, some of which are made unconsciously, some accidentally, some involuntarily. Decisions to head toward a particular occupation or away from it frequently are irrevocable in that once made, they precipitate action that makes the individual ineligible for other fields. For example, a decision not to study algebra and chemistry in high school practically prevents a person years later from becoming a chemical engineer. In addition, since sometimes the decision is made by a process of elimination and since often inconsequential things in the life of an adolescent are thrown into the balance in career decisions, it is important that the individual be exposed to as many types of work and study as his abilities permit so that he has the opportunity to accept or reject occupations demanding a high level of skill and preparation. He must have knowledge about himself, about many careers, and about the compensations which some effort on his part will bring. Exposure to certain subjects basic to scholarly careers, to effective guidance, and to excellent teaching form a learning experience in which his motivation for college can develop. Finally, it would appear that family backgrounds can serve to encourage good motivation.

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[85] For a more detailed interpretation of vocational decision-making see Super, "A Theory of Vocational Development," *American Psychologist*, vol. 8, no. 5 (May, 1953), pp. 185–190; Ginzberg, Ginsburg, Axelrad and Herma, *Occupational Choice*.

Another way in which we can see the importance of motivation as an encouragement factor to college or science is to look at the records of those who drop out of school along the way. Recently a study of early school leavers in Providence, Rhode Island, revealed that intelligence was not as significant a factor as lack of interest in a pupil's withdrawal. Nearly two-thirds of the early school leavers were getting passing grades when they left school. Another study made by the National Child Labor Committee of a group of pupils who left from grades seven to 12 a decade ago revealed that approximately 5 per cent of them had IQ's of 115 or higher, that 36 per cent of them left because they preferred work to school, 11 per cent because they had no interest in school work, 22 per cent for other reasons relating to school, and 21 per cent for financial reasons.[86]

At a higher academic level, lack of motivation is a greater barrier to college attendance. In New York State in 1950, 25 per cent of public high school graduates listed lack of motivation as the reason why they did not intend to study further. Less than 10 per cent cited lack of funds as a reason and 22 per cent revealed other reasons for their failure to go on. In other words, 45 per cent of those not going on to college were not going for lack of motivation.[87] One-half of the boys included in the study reported on by Kahl chose not to go beyond the high school level even though they had the intelligence to do so.[88] Of the group in Minnesota whom Ralph Berdie studied, 63 per cent of those planning on working after high school graduation indicated they would not bother to go to college even if they had more money.[89]

Motivation for a particular job is frequently lacking or misdirected even among those in college. In a survey Webb made at two universities, over half of the men and 60 per cent of the women had either made no choice of a vocation or were uncertain their choice was the right one. Apparently about half of the college students change their vocational objective somewhere along the line from freshman to senior year.[90] Such a high degree of indecision and lack of motivation suggests that recruitment efforts should not force occupational choice too early. It also suggests that to be effective this recruitment must be realistically designed to attract adolescents in terms which they will understand and accept. We cannot show a youngster something that has little or no meaning for him and expect him to respond. To "sell" research chemistry or electrical engineering to a young high school student it is necessary not only to provide him with adequate information but also to make it attractive to him to make the sacrifices necessary to reach such a goal.[91]

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[86] Dillon, *Early School Leavers*, p. 50.

[87] Conger, *Lack of Funds and Lack of Motivation as Barriers to College Attendance in New York State*, p. 45.

[88] Kahl, "Educational and Occupational Aspirations of 'Common Man' Boys," *The Harvard Educational Review*, vol. 23, no. 3 (summer, 1953), p. 186.

[89] Berdie, *op. cit.*, p. 143, 223, 230.

[90] Webb, "Occupational Indecision among College Students," *Occupations*, vol. 27, no. 5 (Feb., 1949), p. 33.

The use of all these potential encouragement factors, then—the school, the teacher and counselor, the industrial and professional society, and the federal and state governments—should be directed toward giving as much information and guidance as possible, providing as much financial support as is necessary, and insuring maximum flexibility in occupational decision-making so that the young person with ability will be able to select engineering or science or any other specialized career when he is ready to make up his mind. At the very least, those who can so effectively encourage college-going should endeavor to see that every able boy and girl is in the developed potential of high school graduates who have been encouraged to go as far as possible with their schooling and have been advised to include the basic mathematics and science courses in their secondary school programs.

However, while these encouragement factors exist, the situation appears to get more and more desperate. Next year more pupils than ever will be deprived of an adequate education. Next year the size of classes in elementary and secondary schools will increase further; the school guidance program, such as it is, will be curtailed; the shortage of teachers will be more pronounced. Classes for gifted pupils, especially in advanced mathematics and science subjects, will be dropped. Meanwhile, as a nation, we shall continue to waste our intellectual resources by failing to provide sufficient aid to those who are prevented by financial reasons from continuing their education and by otherwise allowing talented boys and girls to be deterred from scholarly careers.

What about the boys and girls themselves? How do high school students feel about college and careers in science and engineering? How many able secondary school graduates now intend to continue their education? What has influenced them in their decision? What is their attitude toward the mathematics and science courses they have taken? What do they know about scholarships? It is to these and related matters we now turn.

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[91] For additional consideration of this point, see Henry (ed.), *Adolescence*, p. 214.

The national study of high school students and their plans

Although there are a number of useful local and state-wide studies available on the college-going intentions of high school students, up-to-date nation-wide information on their educational and professional plans has been lacking. Previously published studies have also yielded helpful information on the graduates of individual high schools or colleges. However, it would be hazardous to project these findings in estimating national figures because of their institutional or geographic limitations. Furthermore, the contemporary school population may differ from older ones, making it unwise to draw too heavily from earlier findings. In order to make the estimates sought for in this study, it was considered desirable to have some current figures on which to base them.

Accordingly, a questionnaire and test survey of a national sample of public high school students was made in the spring of 1955 to supply data for this report. The survey, called "A National Study of High School Students and Their Plans," was planned and carried out with the assistance of the Educational Testing Service.[1] The survey questionnaire was designed to provide information on adolescent motivation for college, interest in science, financial plans, and parental backgrounds. In addition to securing information on the factors determining whether or not an intellectually gifted high school student goes to college, we hoped to gain through the questionnaire some idea of what effect the offer of a scholarship would have in drawing persons away from their subject of primary interest. Accompanying the 30-minute questionnaire was a 15-minute test of academic aptitude, and the combined questionnaire and test forms were given to the twelfth-grade students enrolled in a 5 per cent sample of the public high schools with seniors in the United States. A fact sheet asking principals of these schools about pertinent school and community characteristics supplemented the student questionnaire. In every fifth school among those surveyed, the questionnaire was submitted to sophomores as well as seniors.

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[1] The details of planning and administering the National Study of High School Students and Their Plans were under the direction of Drs. Glen Stice, Warren Torgerson, and William G. Mollenkopf of the Educational Testing Service. The questionnaire used in this study is given in Appendix C, p. 223.

The schools used for the sample were selected by designating every twentieth one from a United States Office of Education list of public secondary schools with twelfth-year students. The schools on this list were arranged by major geographical region (West, Northeast, Central, and South) and ranked in order of size within each region. The numbers of students in the sample attending different sizes of schools in different regions were thus proportional to the numbers of such students in the entire population.

The principals of 585 of the 804 schools chosen in this manner agreed to participate in the study. It was estimated that 40,000 twelfth-grade students were enrolled in these 585 schools, or 87 per cent of the students in the original 5 per cent sample. By the time it was necessary to begin analyzing the survey returns, a total of 32,750 questionnaires, filled out by the seniors in 478 schools, had been received. The replies represent approximately 75 per cent of the students in the original sample.

There are a number of possible sample biases which should be borne in mind in interpreting the study data. To check on one source of bias, 20 per

TABLE 14

SCHOOLS IN THE STUDY *and schools in the nation by size and region*[a]

	Schools in nation		*Schools in study*	
SIZE BY ENROLLMENT				
501 or more	2,876	18%	114	24%
201–500	4,215	26	152	32
101–200	3,913	24	107	22
51–100	3,133	20	67	14
0–50	1,912	12	38	8
Total	16,049	100%	478	100%
REGION[b]				
West	1,717	11%	60	12%
Northeast	2,308	14	90	19
Central	5,903	37	166	35
South	6,121	38	162	34
Total	16,049	100%	478	100%

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[a] Schools in the nation figures include all public secondary schools having twelfth-grade students; schools in the study figures include all such schools which originally agreed to cooperate in the study and returned questionnaires.

[b] It is estimated that the twelfth-grade students in the 478 schools in the study constitute a valid sample of 74 per cent cent of all twelfth-grade public secondary school students in the nation. The students in the study similarly constitute valid samples of the following percentages of all such students in each region: West, 76%; Northeast, 81%; Central, 75%; and South, 67%.

cent of the schools that had originally failed to respond were persuaded to cooperate after the initial returns had been tabulated. On the basis of a special analysis of the data from these schools, slight differences were found with respect to some of the responses. But since no differences were large enough to affect appreciably the results here presented, no corrections for sample bias on this score seemed necessary. In considering other possible sources of bias in the survey's results, it should also be noted that the proportion of smaller high schools in the sample is not as large as their proportion in the nation. This is shown in the first part of Table 14, which compares the proportion of schools of various size in the sample with their proportion in the nation. Table 14 also compares the regional proportion of schools in the study and of all senior high schools in the nation. A slightly smaller response was obtained from small schools in the South and Midwest than from those in the West and Northeast, a fact not apparent in the table.

The brief academic aptitude test that was administered to the students participating in the study consisted of 20 questions on words and arithmetic taken from past tests developed by the Educational Testing Service. These 20 individual test items had shown high validity and reliability in previous use. In addition, the test as a whole was pretested in a number of schools during the fall of 1954. Nevertheless, the results on such a short test, regardless of the excellence of the individual items, must be interpreted with caution. Inasmuch as some tests of college ability are thought to discriminate against girls and favor boys, it should be said that this test appeared to function equally well for both. The proportion of boys to girls in the total sample was approximately the same as the proportion of boys to girls in the group scoring in the top 30 per cent on the test.

Other possible biases may have stemmed from the fact that the questionnaire and test forms were in most cases administered in February. We thus have reason to believe that it may have been given only to June 1955 graduates and not to those who graduated in February 1955. However, since it is likely that June and February graduates are drawn from essentially similar populations, any bias resulting from the omission of February graduates should be negligible. On another point, a number of schools reported that their absences due to illness were relatively high in February. Should a tendency toward illness be related to socio-economic level or to ability, this would have some biasing effect. But it is our belief that this effect should also be negligible. In summary, considering all the influences that acted to reduce the size of the original school and student sample, we believe that the survey results are reasonably close to those that would have been given by the full 100 per cent sample.

Two final cautions should be stated. First, we have considerable evidence showing that high school students are frequently inaccurate in reporting certain facts about themselves or their backgrounds. Their reports on their own class standings, for instance, are known to be notoriously unreliable. In his study of Minnesota high school students, Berdie discovered that there was often wide disagreement between the answers of students and their parents to the same questions. The only item on which they had consistently agreed in his survey was on the presence of running water in the home.[2] The second point on which readers should be cautioned concerns the exclusion of independent secondary schools from the study. Because of serious time and financial limitations, it was unfortunately impossible to compile a complete list of private schools similar to the one used for public schools, and to take other steps that would have given an independent school student sample which could have been combined with the one for public school students. Although we have concluded that our public school sample reasonably approximates the entire secondary school population, we believe that a separate study of private school students would still be most worth-while.

In compiling the survey data, the questionnaire responses of 9,689 of the participating seniors were fully scored and analyzed. This group scored 12 or higher on the ability test and was assumed to have sufficient ability to do college-level work. These students were designated "high scoring," and represented approximately the top 30 per cent of the entire sample. The statistics for seniors presented and discussed in the balance of this section are based on the replies of this group. Understandably, this top 30 per cent was not distributed evenly among all four regions. As reported in a previous section, 35 per cent of the seniors tested in the western states scored 12 or higher, as did 34 per cent of those in the Northeast, 29 per cent in the central states, and only 20 per cent in the South.

In devising the questions to be asked these high school students we hoped to test a number of hypotheses that have been advanced regarding college-going and interest in science. For instance, we wanted to see whether or not interest in college was greater among students from professional groups than among those from farm or labor classes. We wanted to observe whether or not there was a direct relationship between college-going and the level of parental education, high school grades, and intellectual ability. We hoped to discover to what extent guidance was linked to college attendance. We desired to test the hypothesis that financial need was an important barrier to college among those with high ability. We wished to see to what extent lack of motivation for college was found among superior students. We hoped to discover whether, in recruiting for certain professions at the high school level, there was danger of drawing persons away from their fields of primary interest. We also wanted to see whether there were any clearly defined reasons in the minds of contemporary adolescents for obtaining a higher education.

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[2] Berdie, *After High School-What?*, p. 90.

As our primary purpose in the National Study[1] was to gather data for estimating the loss of talented students from high school to college, let us first consider what the high-scoring seniors revealed about their college-going plans and various factors affecting those plans. In the questionnaire the seniors were asked what they would *really like* to do when they finished high school. They were given a choice of one of the following: (1) go to college; (2) work for a year or two and then go to college; (3) get a part-time job and go to college; (4) get a full-time job and go to college at night; (5) go to a trade school or take other special training; (6) get a job; (7) become an apprentice; and (8) other. They were then given the same choices and asked what they thought they would actually do when they finished high school. The answers to these two questions served as a basis for classifying the students with regard to their college plans. The following categories were used: (1) going to college now; (2) going to college later; (3) interest in college but no plans to go; and (4) no interest in and no plans for college.

In answering these two questions, 51 per cent of the high-scoring students said that they would really like to go to college full time immediately after high school but only 45 per cent expected to be able to do so. In 23 per cent of the cases, college attendance at some time in the future was checked as the thing the student would really like to do, while in 26 per cent of the cases it was checked as the thing the student would be able to do after working awhile. A full tabulation of the seniors' responses on what they thought they would actually do after high school—their plans with respect to college—is given below. Approximately 14 per cent of the high-scoring group say they have no interest in or desire to attend college, it will be noted. Approximately 6 per cent report that they have a strong interest in college but see no way of ever being able to go. The remaining 10 per cent could not be definitely classified because of the nature of their replies.

Later in the questionnaire the students were asked, if they did plan to go to

College plans of high-scoring seniors

	Going now	*Going later*	*Interest only*	*No interest*	*Miscellaneous*
Boys	47%	31%	4%	9.5%	8.5%
Girls	42	20	8	18	12
Boys & girls	44.5	25.5	6	13.5	10.5

college, what subject they would probably major in and what subject they would really be most interested in studying in college. Under this question a wide variety of subjects was listed. In some cases, what the individual checked as the probable field of major study and what he or she was primarily interested in studying were the same thing. There are some significant differences, however, which showed up in the full tabulation. Table 15 summarizes the answers to this question.

TABLE 15

MAJOR FIELD OF COLLEGE STUDY—*probable and preferred, for high-scoring seniors who plan to go to college*[a]

Major field	*Boys*		*Girls*	
	Probable field of study	*Preferred field of study*	*Probable field of study*	*Preferred field of study*
Physical Science	19%	8%	5%	2%
Pre-medicine, dentistry, nursing	10	6	17	12
Engineering	38	24	1	0
Mathematics	15	3	6	2
Biological sciences	7	2	5	2
Social Sciences	10[b]	2	14[b]	6
Liberal Arts	20[b]	7	20[b]	8
Fine Arts	6	3	14	8
Business	20[b]	7	21[b]	9
Education (teaching)	6	1	22	10
Coaching	8	3	3	2
Agriculture	8[b]	3	0	0
Home Economics	0	0	10	4
Others	..	31	..	35
Total		100%		100%

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[a] Only those who planned to go to college were asked to answer this question. In the questionnaire, these students were asked to circle on the answer sheet the field they would probably study. Then they were asked to indicate the field they would really be most interested in studying by blackening this circle or drawing a new circle and blackening it. However, because over three-quarters of the students indicated more than one field of major interest, the "probable field of study" figures above should be taken as only a very rough approximation of the percentages of these students that will actually major in the fields as listed when they go to college.

[b] Responses to several related choices of answer on the questionnaire have been combined to give these figures. In addition, because individual students in many instances gave multiple answers to the question, the percentages indicate the proportions of checked categories rather than individual student cases.

The students were also asked, "Why do you want to go to college?" In this question they were given the opportunity to circle as many reasons as they considered important and to indicate which, in their opinion, was the most important. Even those who did not plan to go to college were asked to answer. The most significant finding to emerge from this question was the strong vocational reason students have for going to college. Forty per cent of the high-scoring group checked as their most important reason, "A college degree is necessary for the kind of work I want to do." Table 16 presents a full breakdown of answers to this question.

TABLE 16

REASONS FOR WANTING TO GO TO COLLEGE *given by high-scoring seniors*

	Boys		*Girls*	
Reason	*Important*	*Most Important*	*Important*	*Most Important*
Degree needed for career	64%	40%	48%	30%
Financial and business rewards	76[a]	14	50[a]	8
Desire to explore several lines of work	29	10	29	12
Enjoy studying	23	5	33	9
Desire for social development	58[a]	2	. .	8
Social pressure	47	2	46	2
Athletic attractions	11	2	1	0
Prestige	24	1	20	2
Miscellaneous	. .	24	. .	29
Total		100%		100%

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[a] Responses to several related choices of answer on the questionnaire have been combined to give these figures. In addition, because individual students gave multiple answers to the question, the percentages indicate the proportions of checked categories rather than individual student cases.

In the immediately following question the students were asked, "If you do *not* go to college what will the reasons probably be?" In the instructions the students were asked to circle from one to three answers. The results indicate how important the cost factor is in determining whether or not a person goes to college. Remembering that multiple answers could be given, 12 per cent of the group indicated that if they did not go to college the most important reason would be because it would cost more than their family could afford. Almost half of the high-scoring group indicated that expenses would be an important reason why they might not get to college. Table 17 gives the distribution of answers to this question.

TABLE 17

POSSIBLE REASONS FOR NOT GOING TO COLLEGE *given by high-scoring seniors*

	Boys		*Girls*	
Reason	*Important*	*Most Important*	*Important*	*Most Important*
Expense	46%	13%	50%	11%
No college goal	24[a]	5	46[a]	9
Personal inadequacy	25[a]	4	15[a]	2
Family and social pressure	20[a]	3	24[a]	3
Can think of no reason for not going	18	3	15	2
Miscellaneous	. .	72	. .	73
Total		100%		100%

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[a] Responses to several related choices of answer on the questionnaire have been combined to give these figures. In addition, because individual students gave multiple answers to the question, the percentages indicate the proportions of checked categories rather than individual student cases.

In addition to inquiring into their reasons for attending and for not attending college, we gave the students in our survey who planned to go to college a wide variety of choices in answering the following question: "What reasons will be important in deciding what college you will attend?" The instructions were to circle one to three reasons and to indicate which would be the most important one for selecting a particular college. Significantly, 32 per cent of those replying cited the academic reputation of the college as the primary reason for selecting a particular school. Here again the cost factor appears as an important influence on college-going; 16 per cent of the sample circled expense as one of the important factors in their choice of a particular institution. Table 18 presents the breakdown of answers to this question.

TABLE 18

PROBABLE REASONS FOR SELECTING A COLLEGE *given by high-scoring students who plan to go to college*

	Boys		*Girls*	
Reason	*Important*	*Most Important*	*Important*	*Most Important*
Quality of training	88%[a]	33%	76%[a]	30%
Cost	46	17	42	15
Nearness to home	28	5	24	4
Availability of scholarships and financial aid	21[a]	4	13[a]	2
Admission requirements	18	4	13	2
Social factors	41[a]	3	47[a]	4
Religious factors	5	2	9	3
Miscellaneous	. .	32	. .	40
Total		100%		100%

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[a] Responses to several related choices of answer on the questionnaire have been combined to give these figures. In addition, because individual students gave multiple answers to the question, the percentages indicate the proportions of checked categories rather than individual student cases.

In examining these questionnaire replies, one is struck by the extent of determinism apparently involved in going to college. Revealing data can be uncovered, for instance, about the background characteristics of students which might be related to their college plans. As the size of the family increases, for instance, the number of boys and girls going to college now decreases. Approximately half of those in the high-scoring group with one or two brothers or sisters plan to continue their education full time. Only 25 per cent of the boys and 17 per cent of the girls with five or more siblings have such intentions. As might be expected, failure to go to college for financial reasons and also lack of motivation for college are found much more frequently in large families than in small ones.

Also confirmed by the study was the fact that the more formal education a student's father has had, the greater the likelihood of his planning to go to college. Only one-quarter of the high-scoring students whose fathers failed to finish grade school intend to go to college while 70 per cent of those whose fathers graduated from college want to continue their own education. Similarly, lack of interest in a college degree was much less frequently found in the homes of the college-educated than in those where the parents had only an elementary or secondary school education. While only 3 per cent of the high ability seniors whose fathers have a graduate degree report no motivation for college, 15 per cent of the boys and 28 per cent of the girls whose fathers' education was limited to elementary school have no interest in college.

Table 19 illustrates the relation between the parental occupation and the college plans of senior boys and girls in the top 30 per cent of the sample. If we consider together the categories of those students going to college now and those hoping to go later for each of the professional parent groups, between 90 and 95 per cent of the boys expect to be able to continue their education. For the business and technical groups the corresponding percentage for boys drops to about 85, while for farm and labor groups it drops to about

TABLE 19

FATHER'S OCCUPATION *and college plans for high-scoring seniors*

Father's Occupation	*Going Now*		*Going Later*		*Interest only*		*No interest*		*Miscellaneous*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
PROFESSIONAL										
Scientific, non-medical	65%	69%	25%	10%	1%	3%	4%	10%	5%	8%
Education (non-college)	61	70	34	20	0	1	4	3	1	6
Medical	83	84	12	10	0	2	4	2	1	2
Other	59	75	35	14	1	3	2	3	3	5
BUSINESS										
Supervising	61	55	24	16	2	4	6	13	7	12
Non-supervising (high level)	63	63	28	11	2	7	3	10	3	9
Non-supervising (low level)	56	50	29	20	3	5	6	14	6	11
Technical	55	49	31	22	2	2	7	12	5	15
Farm	38	38	29	22	6	9	11	19	16	12
LABOR										
Skilled	32	24	37	25	5	11	15	26	10	14
Semiskilled	28	21	37	22	5	14	19	26	11	17
Unskilled	32	24	38	24	7	12	12	25	12	15
Other	33	. .	35	. .	6	. .	14	. .	11	. .

65 per cent. There is also an increase in the "no interest" category for boys in the farm and various labor groups. For girls the same trend appears to hold. However, there are generally smaller proportions planning to go to college now or later throughout the table for girls than there are for boys.[3]

Comparing only the responses reported in the first column in Table 19 points up the sharp difference in immediate college-going among different economic groups. It will be seen that whereas 65 per cent of high ability boys whose fathers are in scientific professions and 83 per cent of those whose fathers are in medicine intend to go to college without delay, only 28 per cent of those whose fathers are in semiskilled occupations intend to do so and only 38 per cent of those whose fathers are farmers plan to go to college immediately. Among high ability girls the variation is even greater. Although a slightly higher proportion of girls from professional homes intend to go to college immediately, only 21 per cent of those with fathers in the semiskilled category intend to do so.

The "interest only" column in this table may reflect in some measure how strongly financial need deters college-going. Although virtually none of the high ability boys from professional homes indicate they want to go to college but cannot, 7 per cent of those whose fathers are unskilled workers make this statement. In addition, the differences in the proportion among the economic groups who indicate deferred college plans may also reveal the presence of financial barriers. One-quarter of the high-scoring boys from the homes of non-medical scientists say they intend to go to college later or combine it with a job. Among the able boys from laboring families the proportion is between 35 and 40 per cent. A similar picture exists with respect to girls. On the other hand, the responses listed in the "no interest" column may throw some light on the matter of motivation. The lack of motivation for college is shown by no more than 4 per cent of the boys from professional homes while it is apparent in the responses of 19 per cent of the high ability sons of semiskilled laborers. One-quarter of the high ability daughters of skilled and semiskilled laborers indicate no interest whatever in going to college.

Other findings in the study showed that the proportion of those going to college now who have friends expecting to go to college is much higher than for those who have few college-bound friends. Of those who express no interest in going to college, a much higher proportion have friends who do not expect to continue their schooling. This trend is even more pronounced for girls than for boys. Over one-third of the girls with few friends going to college indicated that they had no interest in continuing their education. On the other hand, only 8 per cent of those whose friends are going revealed a lack of motivation for college.

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[3] Because these figures apply solely to high ability seniors they are higher than the comparable estimates made by Wolfle in illustrating the relation between college-going and father's occupation. He estimated that two-thirds of the high school graduates whose fathers were in professional or semi-professional occupations enter college, one-half of those whose fathers hold managerial positions do so, while among the children of farmers and factory workers only one-quarter of the high school graduates entered college. See Wolfle, *America's Resources of Specialized Talent*, p. 160.

Table 20 reveals the relation between ability test scores and college plans. It will be noted that the higher the score on the ability test administered with the questionnaire, the larger the percentage of seniors planning to go to college. Conversely, the lower the score, the greater the percentage expressing no motivation for college. This is similar to the picture for Minnesota high school seniors as reported by Berdie.[4] Another pattern is revealed by comparing the relation of school size to college plans. As the figures in Table 21 indicate, the proportion of pupils planning to go to college increases as the size of the school increases with the exception of the very large schools having enrollments of over 1,500. In these schools, there is a sharp drop in the percentage planning to continue their education.

TABLE 20

TEST SCORES *and college plans for high-scoring seniors*

Test Score	*Going Now*		*Going Later*		*Interest only*		*No interest*		*Miscellaneous*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
12	37%	32%	30%	20%	5%	9%	16%	23%	12%	16%
13	36	35	34	18	5	9	13	24	12	14
14	44	39	31	21	5	8	11	19	9	13
15	45	43	34	19	4	7	7	18	10	13
16	54	48	29	21	3	8	9	13	5	10
17	56	52	32	23	3	5	5	10	4	10
18	62	53	28	22	2	6	4	9	4	10
19	66	57	25	22	2	4	2	8	5	9
20	72	65	24	21	0	2	1	5	3	7

TABLE 21

SCHOOL SIZE *and college plans for high-scoring seniors*

Size by enrollment	*Going Now*		*Going Later*		*Interest only*		*No interest*		*Miscellaneous*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
0–99	37%	40%	32%	17%	5%	10%	13%	22%	13%	11%
100–299	40	37	31	22	5	9	10	17	14	15
300–599	45	44	34	19	3	8	10	17	8	12
600–999	51	44	27	17	3	7	10	18	9	14
1,000–1,499	56	46	29	19	3	8	6	16	6	11
1,500 or more	43	39	33	24	4	6	12	19	8	12
Average	47%	42%	31%	20%	4%	8%	9%	18%	9%	12%

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[4] See Berdie, *After High School–What?*, pp. 98–111.

The questionnaire results also throw some light on the present vocational interests of the able high school senior. The students in our sample were asked, "Think about what you would like to be 15 years from now. Suppose that with hard work you would be successful in whatever you choose. Indicate what occupation you would choose to make your goal." Approximately one-quarter of the boys in the high ability group say they would like to become engineers. About 10 per cent want to go into business, 8 per cent into medicine, and 8 per cent into other unspecified professional fields. Approximately 6 per cent would like to become physical scientists. Only 1 per cent aspire to become social scientists. Four per cent of the boys in the upper 30 per cent group aspire to the educational profession. But the number who want to be athletic coaches is three times as large as the number who want to be classroom teachers.

About 20 per cent of the high-scoring girls, however, would like to be in education 15 years from now, 18 per cent in white-collar jobs, and 12 per cent in nursing and medical technical work. Evidently 12 per cent of them desire solely to be housewives 15 years from now. No more than 1 per cent of the high ability girls wish to enter science or engineering, both of which continue to be masculine occupations in the eyes of adolescents. A full tabulation of these vocational aspirations is presented in Table 22.

Although an encouraging percentage of these high-scoring boys indicate

TABLE 22

IDEALIZED VOCATIONAL ASPIRATIONS *of high-scoring seniors*

Vocation	*Boys*	*Girls*
Engineering	26%	0%
Professional, nonspecified	8	5
Physical science	6	1
Biological science	1	0
Social science	1	1
Medical professions	8	3
Law and politics	4	1
Literature and arts	3	8
Religion and social welfare	2	4
Education	4	20
Technical	3	2
Medical technical	0	12
Business technical	2	0
Farm	4	1
Business	10	5
White collar	4	18
Skilled labor	4	0
Other labor (including housewife)	1	12
Miscellaneous	9	6

an interest in engineering, it is worth noting that only 53 per cent of them plan to go to college immediately. Fifty-seven per cent of those interested in natural science and mathematics intend to do so. Even when those who intend to go to college later are included, about 10 per cent of the high ability boys interested in scientific and engineering fields are presumably lost to these fields because they cannot or will not go to college.

TABLE 23A

VOCATIONAL ASPIRATIONS *and father's occupation for high-scoring senior* BOYS

	Parental Occupation								
Student vocational aspiration	*Professional, scientific*	*Professional, non-scientific*	*Technical*	*Business, supervisory*	*Business, non-supervisory*	*Farm*	*Labor*	*Other*	*All*
Engineering	28%	19%	23%	28%	24%	19%	28%	24%	26%
Natural science and mathematics	10	10	9	5	8	8	6	8	7
Medical professions	17	10	8	10	10	4	5	4	8
Law and politics	4	10	4	6	5	2	3	4	4
Literature and social welfare	5	8	7	4	6	3	5	6	5
Education	1	6	5	5	4	7	5	4	5
Other professions	8	8	6	7	9	6	9	8	8
Technicians (all kinds)	4	4	13	4	4	3	7	5	5
Business	10	9	8	15	10	6	8	12	10
White collar	2	2	3	4	6	3	4	2	4
Farm	3	2	2	1	2	25	2	3	4
Skilled labor	1	0	3	2	2	4	8	4	4
Other labor	1	1	1	1	1	1	1	4	1
Not classified	6	11	8	8	9	9	9	12	9

The questionnaire design also made it possible to see what relation there might be between parental occupation and the occupational aspirations of these students. Table 23A gives a breakdown by father's occupation of percentages of high-scoring boys who have particular vocational aspirations; Table 23B gives a similar breakdown for high-scoring girls. (The vocational aspiration categories used here, it should be noted, do not exactly parallel those given in the preceding table.) These figures suggest how much social mobility there is in the occupational plans of able high school students. While only 11 per cent of the fathers of this group of boys were in the various professions, 63 per cent of these boys aspire to a profession. The figures suggest that, with a few exceptions, the children of parents in a given occupation are slightly more likely than children in general to go into this occupation. The outstanding example of this appears to be in farming. Only 4 per cent of the high-scoring boys plan to go into farming but one-quarter of those who are sons of farmers have this intention.

TABLE 23B

VOCATIONAL ASPIRATIONS *and father's occupation for high-scoring senior* GIRLS

	Parental Occupation								
Student vocational aspiration	*Professional, scientific*	*Professional, non-scientific*	*Technical*	*Business, supervisory*	*Business, non-supervisory*	*Farm*	*Labor*	*Other*	*All*
Engineering	1%	1%	0%	1%	0%	0%	0%	0%	0%
Natural science and mathematics	5	3	2	2	2	1	2	2	2
Medical professions	6	7	2	3	3	2	2	2	3
Law and politics	1	1	2	3	2	0	1	1	1
Literature and social welfare	18	17	9	13	12	10	9	11	11
Education	19	26	23	21	21	25	17	14	20
Other professions	9	8	11	6	7	4	5	7	6
Technicians (all kinds)	11	11	18	15	14	15	17	14	15
Business	5	4	4	4	6	5	4	4	5
White collar	9	5	11	12	14	18	24	27	18
Farm	1	0	0	0	1	2	1	1	1
Skilled labor	1	0	0	0	0	0	0	0	0
Housewife	9	13	13	13	11	15	13	11	12
Not classified	5	4	5	7	7	3	5	6	6

As previously stated, we were particularly interested in investigating the influence of scholarships on college-going, and consequently included in the questionnaire a number of questions relating to scholarships. In one the students were asked, "Suppose that you would get a scholarship to go to college if you agreed to study a particular subject. The scholarship would be large enough to make it possible for you to attend a good college and you would have no need to worry about earning any part of your expenses. *But to get the scholarship you would have to agree to major in (or emphasize) some particular subject.*" Sixty-one per cent of the boys in the top 30 per cent would "certainly" or "probably" accept a scholarship to study engineering, but only 5 per cent of the girls would do so. Fifty-one per cent of the boys indicated they would accept a scholarship to specialize in the physical sciences, 21 per cent of the girls would do so. Thirty-two per cent of the able boys would accept a scholarship to study in one of the biological sciences. Such a scholarship would attract 27 per cent of the girls. Twenty-six per cent of the boys were willing to accept scholarship aid that required them to major in the social sciences, 30 per cent of the high-scoring girls would do so. Of the high-scoring boys, 48 per cent were willing to major in mathematics under such circumstances while only 24 per cent of the girls are in this category. The liberal arts (languages, philosophy, literature) attracted a similar answer from 29 per cent of the boys and 48 per cent of the girls, while to receive scholarship assistance only 17 per cent of the boys and 41 per cent of the girls would do undergraduate work in the fine arts. The percentages willing to study in business are 42 per cent of the boys and 48 per cent of the girls. Scholarships for study in education would attract only 28 per cent of the boys and 52 per cent of the girls. Agriculture under such an arrangement would attract 23 per cent of the boys and 6 per cent of the girls.

The most revealing use that can be made of these scholarship figures is to compare them with the answers given previously to the question about what subject the student would really be most interested in studying in college. By contrasting what high school students say they would like to do with what they say they would do under the encouragement of scholarship aid, we can assess to some extent the diversion through financial incentives from one field to another, and also the degree of commitment of individuals in the face of strong financial pressures. By comparing these two sets of answers a "subject seductivity index" can be discovered. For instance, if we consider only those who intend to go to college, almost one-half of those in this high-scoring group who expect to study fine arts and education would accept a scholarship to study engineering, while less than one-fifth of those who expect to major in the physical sciences or engineering would accept a scholarship that restricted them to major in the social sciences.

Some of the individual areas of defection are worth noting. As shown in Table 24, 72 per cent of the high-scoring boys expecting to study in the physical sciences would accept scholarships in engineering. About 30 per cent of those who are interested in the nonscientific areas of the liberal arts would accept scholarship aid to major in mathematics, the physical or biological sciences, and engineering. Thirty-five per cent of these high ability boys who plan to major in social science will defect to physical science. It is not surprising to observe that 72 or 73 per cent of those who list medicine as first choice will readily major in physical or biological science on a scholarship but only one-third of them would do so to study engineering.

Looked at another way, scholarships in the physical sciences offered to this able group of boys would attract 35 per cent of those primarily interested in

TABLE 24

WILLINGNESS TO ACCEPT SCIENCE SCHOLARSHIPS *and probable major study in college for high-scoring seniors who are interested in or planning to go to college*

	Per cent that would give up probable major to accept a scholarship in:									
Probable	*Engineering*		*Physical Science*		*Biological Science*		*Social Science*		*Mathematics*	
Major	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
Engineering	99%	0%	71%	0%	25%	0%	15%	0%	74%	0%
Physical sciences	72	18	96	98	45	71	18	29	58	54
Biological sciences	30	5	57	70	96	95	30	32	15	26
Medical pre-professional	33	8	72	56	73	60	25	34	34	29
Social science	27	2	35	19	39	33	77	72	31	22
Mathematics	80	29	67	46	32	33	19	33	96	99
Liberal arts	30	3	31	17	28	22	66	48	30	21
Fine arts	46	5	37	12	28	19	31	24	33	17
Education	34	4	26	12	31	19	50	31	46	26
Coaching	48	2	37	13	28	35	33	33	44	15
Business	41	5	27	10	20	14	38	25	46	30
Agriculture	46	4	34	14	32	24	14	34	32	18
Miscellaneous	56	7	48	19	34	27	28	33	44	25

the social sciences, 27 per cent of those interested in business, and 26 per cent of those interested in education. One might ask whether high-scoring boys with a primary interest in coaching would have any interests or aptitudes in the direction of physical science, yet 37 per cent in this group would accept financial aid that required them to major in physics or chemistry. Scholarships offered for study in engineering would siphon off 72 per cent of those boys interested in the physical sciences, 30 per cent of those primarily interested in the biological sciences, 46 per cent of those who otherwise plan to major in the fine arts, and 34 per cent of those interested in education. Scholarships for study in education, however, would attract only 18 per cent of those primarily interested in physical science, 19 per cent of those whose first love is engineering, and 34 per cent of those interested in business. The comparable figures for girls indicate less of a willingness to shift from the field of major interest, at least into the sciences. At the same time, it might be noted that one-third of the high ability girls with an interest in social science say they would leave the social science field to major in mathematics. In general, these figures would suggest that the willingness of students to accept a restricted scholarship increases the more nearly its field approaches their area of interest. But the figures also indicate considerable willingness at the high school level to make vocational commitments for what appear to be purely financial considerations.

Serious limitations, of course, must be placed on any interpretation of these figures. Many of the answers given by our 5 per cent sample of the nation's high school senior population may be unreliable. Some of the respondents may have concluded that they could accept a scholarship to study in a number of areas and still devote most of their time to whatever they like best. Many who indicate a willingness to accept a scholarship to major in an area other than that of their primary interest would probably not have the ability or aptitude to secure and keep such a scholarship. In addition, what an adolescent says he would do and what he eventually does may well be strikingly different. Nonetheless, it would appear that the offering of scholarships restricted to particular fields sets in motion gravitational forces of unequal intensity that tend to change the existing distribution of interests in the secondary school population. Furthermore, these different indices of subject-matter seductivity tend to corroborate the view that commitment to some fields comes earlier than it does in others, that deep interest in certain subjects is already apparent by the senior year in high school while in others it has not yet begun to emerge in as large a percentage of the school population. These figures raise some interesting questions in connection with recruitment for science and engineering at the high school level.

In examining the questionnaire replies a comparison was also made between very high-scoring and all high-scoring seniors with regard to the kinds of scholarships they would accept. Very high-scoring seniors were those who constituted approximately the top 10 per cent of our sample. As might be expected, there are outstanding differences between the sexes revealed here. Very high-scoring boys show much greater interest than girls in scholarships in engineering, physical science, and mathematics. A large percentage of the very able girls would accept scholarships in liberal arts, fine arts, and education. Appreciably smaller percentages of both boys and girls in the very high-scoring category are interested in business and education. There appears to be a tendency for a larger proportion of the very high-scoring boys and girls to be interested in the sciences and mathematics, and, particularly in girls, for a greater number of the very high-scoring students to be interested in the liberal arts scholarship.

Other study figures illuminate both the need for scholarships and their possible effect on motivation. Of the boys who would be willing to accept an engineering scholarship, 46 per cent expected to go to college on a full-time basis, while 34 per cent expected to go part time or after a few years' delay. A total of 20 per cent of these boys did not expect to go to college at all. Thus, if all of them were awarded engineering scholarships we could expect that 46 per cent of these scholarships would merely make life easier for the high ability boys who were planning to go to college anyway. It should not be overlooked, however, that such scholarships might make it possible for the recipients to go to a better college. Thirty-four per cent of them would be able to devote more time to their studies and become qualified engineers at an earlier date than is now planned. Twenty per cent of the scholarships would go to people who probably would never get to college without them. In addition, perhaps the fact that over half of the high-scoring boys with no interest in college would accept a scholarship to study engineering and one-quarter of them would accept one for study in the sciences suggests to what extent lack of motivation for college can be replaced by a positive interest when scholarship assistance looms on the horizon.

In order to ascertain the extent to which there is general information about college scholarships among high school students we asked them, "Which of the following types of scholarship have you heard about?" Under the question were listed seven different types of financial aid which, it was believed, were most familiar to high school students. These included the Navy ROTC scholarships, the Seven College Conference Scholarship Program for women, the Westinghouse Science Talent Search Scholarships, the Ivy League national scholarships, local industrial scholarships, state or individual college awards, and special scholarships available only to graduates of the individual high school. In view of the wide variety listed, it is probably surprising that not all students answered that they had heard of more than three of the above. Specifically, 22 per cent of the high-scoring group circled more than three. Twenty-four per cent had heard of only three, 25 per cent of only two, and 20 per cent of only one of the scholarship programs listed. Eight per cent had not heard of any.

Finally, we asked the students, "If you plan to go to college, how do you think your college education will be paid for?" In this question we asked them to estimate approximately what per cent of college costs they expected their family or relatives to pay, what per cent they intended to cover by summer earnings and part-time jobs, what per cent would be paid by a scholarship, what per cent they expected the government to pay (through ROTC, etc.), and what per cent they would need to borrow.

This was the last question on the questionnaire. Many students probably did not have time to do justice to this question. It was too early in the school year for many of them to have heard about scholarships they might have won. Consequently, the interpretation of these answers must be limited.

Several interesting things emerged from these answers. About 8 per cent expected their family to pay all of their expenses and 19 per cent expected their family to pay at least 75 per cent of college expenses; 18 per cent were counting on family support for half their college expenses. Twenty-four per cent did not reply to this question. About 10 per cent of the college-bound boys in the top tenth in ability (according to the survey test) expected to get no financial support from their parents; more than half of them expected to have less than 50 per cent of their college expenses paid by their parents. Of those who answered this question about 49 per cent expected to receive some scholarship aid. A very small number (less than 15 per cent) expected to borrow any amount in order to finance their college education. About one out of every seven of the high-scoring boys indicated that he expected that the government would finance some portion of his college expenses presumably through such means as the ROTC or the GI Bill programs.

TABLE 25

KNOWLEDGE OF SCHOLARSHIPS *and college plans among high-scoring senior* BOYS

Scholarship programs known of	*Total per cent*	*Going now*	*Going later*	*Interest only*	*No interest*	*Miscellaneous*
0 or 1	18%	38%	37%	5%	13%	7%
2	24	46	31	4	10	9
3	26	51	32	3	7	7
4 or more	24	56	30	3	5	6
No response	8	30	28	6	21	2

Pursuing the question of how students might finance a college education, an attempt was made to discover how college plans are apparently influenced by knowledge of scholarships as indicated by acquaintance with the seven types previously specified. Between 70 and 75 per cent of the high ability senior boys had heard of more than one of the scholarship programs listed in the questionnaire. As indicated in Table 25, less than 25 per cent of the boys had heard of more than four of these scholarships. A comparison between interest in college and acquaintance with scholarship information reveals the following: only one-half of all high-scoring students who want to go to college and must go later, and one-half of those who report an interest in college but cannot plan on attending, have heard of two or more scholarship programs. These figures raise a question about the effectiveness of high school counseling. Presumably, the more students in a school who have heard of scholarships, the more attention is being given in the school to college guidance.

One of the hypotheses that it was considered desirable to check in our study was whether there was a direct relationship between high school guidance and college-going. The table directly below reveals the extent to which able high school seniors discuss college-going with school guidance counselors and with their parents. Almost one-fifth of these high-scoring students have not discussed the question of college-going with school counselors or teachers and only about one-quarter of them report discussing the subject in school quite a lot. In some cases, of course, guidance officers are not available to the students.

Discussion of college-going by high-scoring seniors

	With guidance counselors		*With parents*	
	Boys	*Girls*	*Boys*	*Girls*
Quite a lot	25%	28%	64%	66%
Some	58	54	32	29
Not at all	17	18	4	5

Table 26 reveals the incidence of guidance counselors in secondary schools of varying size. Data in this table are based on information supplied by principals in the schools cooperating in the study. The larger the school, the more professional counselors there are likely to be on the high school staff. Even so, 28 per cent of the largest schools in our sample have either none at all or less than one full-time guidance person. Fifty-four per cent of the schools in our study report no professional counselor whatever, even on a part-time basis.

TABLE 26

GUIDANCE COUNSELORS *on the high school staffs in schools cooperating in the study*

		Per cent of schools with specified number of counselors			
10th year class size	*Schools surveyed*	*None*	*One half-time only*	*One full-time only*	*More than one full-time*
157 or more	85	10%	18%	21%	51%
79–156	77	42	23	26	9
41–78	80	56	28	16	0
26–40	81	74	20	6	0
0–25	94	83	13	4	0
All schools	417	54%	20%	14%	12%

TABLE 27

DISCUSSION OF COLLEGE-GOING *and college plans for high-scoring seniors*

Amount of discussion	*Going now*		*Going later*		*Interest only*		*No interest*		*Miscellaneous*	
	Boys	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
WITH SCHOOL COUNSELORS OR TEACHERS										
Quite a lot	67%	64%	27%	21%	1%	3%	2%	4%	3%	8%
Some	46	39	34	22	4	9	8	18	8	12
Not at all	21	17	27	11	6	12	26	39	20	21
WITH PARENTS										
Quite a lot	59	58	32	23	2	4	3	7	4	8
Some	28	11	33	16	7	16	17	36	15	21
Not at all	4	0	11	2	9	8	49	62	27	28

Table 27 is concerned with the relation between college plans and the amount of school and parental guidance. The figures in this table suggest a significant relationship although one cannot conclude that there is necessarily a causal connection. Of the high ability senior boys who have not discussed going to college with their teachers or guidance counselors only 21 per cent intend to go to college right away. Of boys who have discussed the subject to some extent, the percentage planning to go to college immediately is 46. Of boys who have discussed going to college with high school personnel quite extensively, 67 per cent intend to go to college full time. Conversely, while only 2 per cent of the high-scoring boys who have discussed college-going with their teachers or advisers quite thoroughly reveal no motivation for college, 26 per cent of those who have not discussed the subject indicate no motivation for college.

In Table 27 the important role of the parent may also be clearly seen. Of the boys who have not discussed college-going with their parents, 4 per cent are going to college and 49 per cent show no motivation for college. Of the boys who have discussed the subject with their parents quite a lot, 59 per cent are going to college immediately after graduation and only 3 per cent report no motivation for higher education. Obviously, the boys who expect to go to college are the ones who have discussed the subject with their parents, teachers, and counselors. Those who do not expect to go are not as likely to have discussed the subject. But, as stated before, lack of counseling in the home or school need not necessarily be the main reason why many of these high ability boys and girls do not continue their education.

In addition to asking high school seniors about their college plans, the sophomores in every fifth school in the sample were given the test and asked to fill out the questionnaire. We considered it worthwhile to investigate what differences or similarities there might be between the two age groups, both in background and in their thinking about college and careers. Administering the questionnaire to a sample of high school sophomores also provided data on a group which could be reexamined as seniors in 1957 to see what changes had taken place in their academic and vocational plans. As with the seniors, the responses of only the correspondingly high-scoring sophomores were fully tabulated and are presented and discussed here.

It was discovered that the high-scoring sophomores are essentially similar to the seniors in their parental and economic backgrounds. Although the sophomores come from slightly larger families, their fathers' occupations are distributed in about the same proportions as had been found for the seniors. The similarity in their backgrounds is quite striking.

As might be expected, fewer of the high school sophomores have discussed going to college with guidance counselors or teachers. Although over one-quarter of the high-scoring seniors have discussed the subject quite thoroughly with someone at school, only 7 per cent of the sophomores report having done so. On the other hand, 40 per cent of these tenth-graders with what appears to be college-level ability have never discussed college with their teachers or counselors. Insofar as discussion of the subject with parents is concerned, the difference between the two groups is less striking. Nonetheless, no more than half of the able tenth-graders have discussed going to college at home to any great extent, and about 10 per cent of them have not talked with their parents about college at all.

TABLE 28

IDEALIZED VOCATIONAL ASPIRATIONS *of high-scoring sophomores and seniors*

	Boys		*Girls*	
Vocation	*Sophomore*	*Senior*	*Sophomore*	*Senior*
PROFESSIONAL				
Engineering	21%	26%	0%	0%
Natural science and mathematics	7	7	3	2
Medical	8	8	3	3
Education	5	4	17	20
Law and humanities	8	8	8	9
Religion and social welfare	1	2	3	4
Other professional	8	8	5	6
Total	58	63	39	44
NONPROFESSIONAL				
Technicians	7	5	18	14
Business	7	10	2	5
White collar	3	4	22	18
Farming	7	4	0	1
Skilled labor	5	4	0	0
Other labor (includes housewife)	1	1	9	12
All others (includes no response)	12	9	10	6
Total	42	37	61	56

An interesting similarity appears to exist between tenth and twelfth-graders in the occupations they would like to be pursuing 15 years hence. Although there are important differences, Table 28 displays a remarkably similar distribution in the idealized vocational aspirations of the two groups. About the same proportions of both senior and sophomore boys would like to enter professions other than engineering. The major difference appears to be in the percentage in each group who aspire to be engineers; 21 per cent of the high-scoring sophomore boys have engineering in mind as compared with 26 per cent of the high-scoring seniors. This is probably not surprising in the light of the additional knowledge of job opportunities which the high school seniors presumably possess. It is also not surprising to see a decrease in the proportion of high ability seniors who aspire to make farming their career. In the case of girls there is some increase among the seniors in the proportion aspiring to nonscientific professional careers, but there appears to be slightly less interest in scientific and technical occupations among senior girls than among sophomores. The figures in this table throw interesting light on some of the patterns of adolescent occupational thinking.

TABLE 29

POST-HIGH SCHOOL INTERESTS AND PLANS *of high-scoring sophomores and seniors*

After graduation	*Per cent that would like to*				*Per cent that plan to*			
	Boys		*Girls*		*Boys*		*Girls*	
	Soph.	*Senior*	*Soph.*	*Senior*	*Soph.*	*Senior*	*Soph.*	*Senior*
Go to college	42%	53%	47%	50%	39%	47%	37%	42%
Work first, then college	7	7	4	4	10	8	6	4
Job part time and college	21	18	15	13	21	22	16	14
Job and college at night	1	1	1	2	1	1	1	2
All cases with interest in college	71	79	67	69	71	78	60	62
Trade school	5	5	11	9	5	4	10	7
Job	7	4	12	11	12	10	21	21
Apprentice	3	2	0	0	2	2	0	0
Other and no response	14	10	10	11	10	6	9	10

TABLE 30

WILLINGNESS TO ACCEPT RESTRICTED SCHOLARSHIPS *among high-scoring sophomores and seniors*

Scholarship restricted to study in	*Per cent that would accept*			
	Boys		*Girls*	
	Sophomore	*Senior*	*Sophomore*	*Senior*
Engineering	59%	61%	5%	5%
Physical science	43	51	22	21
Biological science	31	32	29	26
Social science	17	26	25	29
Mathematics	50	48	32	24
Liberal arts	23	29	42	48
Fine arts	15	17	46	41
Business	43	41	49	48
Education	31	28	50	52
Agriculture	28	23	8	6

The figures in Table 29 reveal the differences between sophomores and seniors with respect to interest in college and post-graduation plans. As one might expect, interest in college increases from the tenth to the twelfth grade. In the tenth grade, 42 per cent of the high-scoring boys and 47 per cent of the high-scoring girls would really like to go to college full time immediately after high school. Among the high-scoring seniors, the percentages are 53 and 50 respectively. Although 45 per cent of the high-scoring seniors think they will go to college full time right after graduation, only about 38 per cent of the sophomores in this category have similar expectations. The differences revealed here are perhaps partly due to the number of drop-outs that occur between sophomore and senior year; obviously, the twelfth graders have gone through two years more of the winnowing-out process.

TABLE 31

KNOWLEDGE OF SCHOLARSHIPS *among high-scoring sophomores and seniors*

Scholarship programs known of	*Boys*		*Girls*	
	Sophomore	*Senior*	*Sophomore*	*Senior*
None or 1	26%	18%	27%	23%
2	23	24	25	26
3	18	26	17	23
4 or more	11	24	10	19
No response	22	8	21	9

Differences between the two groups in attitudes toward scholarships and knowledge of scholarship opportunities are revealed in Tables 30 and 31. There is an increase between the sophomore and senior years in the proportions of high-scoring senior boys who would accept a scholarship to study in the fields of engineering, physical and biological science, social science, and liberal arts, while the proportions of boys who would accept scholarships to study mathematics, agriculture, or education decrease. Among girls there is a similar decrease in the percentage willing to accept scholarship aid to study mathematics, or a physical or biological science. It would be impossible to say whether or not these differences reflect the influence of the last two years in secondary school. However, if a follow-up study of the tenth graders can be made, changes in their willingness to accept financial incentives to study in certain areas can be explored more thoroughly. From Table 31 it is also evident that tenth graders have less information about scholarships than have seniors.

The reasons for going to college given by the two age groups are contrasted in Table 32. Fewer sophomores answered this question, perhaps revealing greater uncertainty as to the most important reason for their going. At any rate, the high-scoring seniors appear to put greater emphasis on the vocational reasons for a college education. Forty per cent of the high-scoring senior boys say they are going to college because the degree is needed for their work while one-third of the able sophomores give this reason. There also appears to be a slight increase in the proportion of seniors going to college because they like to study. However, this is a small minority among both tenth and twelfth graders.

TABLE 32

THE MAJOR REASON FOR WANTING TO GO TO COLLEGE *among high-scoring sophomores and seniors*

	Boys		*Girls*	
Reason	*Sophomore*	*Senior*	*Sophomore*	*Senior*
Degree needed for work	33%	40%	27%	30%
Financial rewards	12	14	10	8
Explore several kinds of work	9	10	10	12
Enjoy studying	2	5	7	9
Social development	2	2	9	8
Social pressure	2	2	3	2
Athletics	4	2	0	0
Prestige	0	1	1	2
Others (including no response)	36	24	33	29

In the schools in which questionnaires were administered to students, the principals were asked to provide background information on the size and facilities of the school, the nature of the community in which it was located, and the availability of special staff members such as guidance counselors. The principals were also given the opportunity to describe any particular factors which in their opinion either encouraged or discouraged their students with respect to attendance in college. A large number of the principals commented on the subject and their observations provide a useful supplement to the statistical data.

The principals of schools with average or high college-going rates identified those conditions in the school or community which the figures in the preceding pages suggested. Where there was a tradition of college-going in the community, the principals asserted, more of their seniors tended to want to continue their education. The principal of a Connecticut high school wrote, "The parents, being college graduates themselves, help youngsters to decide on college." An Illinois principal observed, "Work conditions for the parents, mostly professional, are good, so pupils can attend college if the desire is present." Many referred to the proximity of a college as an important reason why many of their graduates continue education A few cited the contribution of guidance. "We have had a full-time guidance counselor for only two years," a principal from New York wrote, "and already the increased number of seniors planning on college is encouraging." A few schools reported that there were loans available for those who needed them to attend college.

Many more principals volunteered observations about factors preventing college-going among their pupils. The head of a Nebraska high school wrote, "Very few of our students are encouraged by their parents to attend college." From South Dakota came the comment, "This is a rural community where the parents are indifferent to higher education." From another state came the report, "An almost complete absence of professional people in the community is probably responsible for only a few students going on to college." A Georgia principal was one of many who declared, "Most of our pupils come from tenant farm homes where there is no chance of college. The school is too small to offer college prospects their needs." The head of a school in Pennsylvania wrote plaintively, "There is a terrific pressure on our young to return home after graduation. Parents are relying on their financial support. Have a hard time persuading top graduates to accept scholarships offered." A North Carolina educator facing a different type of problem stated, "Teaching is the only field of employment for Negro students in the local community."

But depressed economic conditions was not the only reason given to explain why education of able pupils frequently stops at the twelfth grade. According to a number of principals, the opposite is the case. An educator in Kentucky wrote, "We are near two factories that employ many young women. They can make more within six months than a college graduate can in several years. Even the smart ones see no reason why they should go to college." A similar report came from Minnesota: "This is a very prosperous farm community. Recognition of the need for a college education among our brighter boys has not arrived." A principal in a western ranching state declared, "Incomes here are high. All our girls are anxious to marry boys with good ranch prospects. Some of the boys have earned more than 5,000 dollars a year throughout high school on ranch operations. College does not offer comparable income opportunities." And from another part of the country came the observation, "The discovery of oil here gives some the impression that education is not necessary."

Some of the school heads cited discouraging conditions in the schools themselves. A Louisiana principal wrote, "Our school is too small to permit hiring the science and language teachers needed for those with college ability." A principal in Nebraska said that most of his graduates did not go on with their education "because of low standards for teachers in rural schools." Another observed, "Former graduates tell us they were poorly prepared for college." A number of principals remarked that their academic programs were curtailed by increased enrollment. As one put it, "Our difficulty is trying to operate a good college preparatory program when everyone now goes to high school." In many instances it was clear that the principals were working to improve those conditions in the school which were unfavorable to college-going. In addition, their comments tended to corroborate the thesis that anything that is done to increase the number of those with high ability who go to college must influence the attitude of parents as well as of their sons and daughters.

Throughout this chapter we have been discussing high school students' plans with no reference to regional differences in college-going. These differences are revealed to a certain extent in Table 33, which lists the percentage of high-scoring seniors planning to go to college now or later by the four major geographical regions. The highest proportion of able senior boys planning to go to college immediately after graduation is found in the northeastern part of the United States, the lowest proportion in the central region. The largest proportions of high-scoring senior girls planning to go to college appear to be in the South and West, and the lowest proportion in the central area. High ability senior boys who are interested in going to college but who don't expect to be able to continue their education seem to be fairly evenly distributed. Among the girls, the proportion with interest in college but no expectation of going is lower for the West than for the rest of the United States. Lack of motivation for college among high ability secondary school seniors appears to be found more frequently in the central region and also in the Northeast, despite the latter's high percentage of boys planning to go to college. It may well be, however, that the distribution of unmotivated high ability persons who left high school early is quite different from that of seniors still in high school because the holding power of high schools varies considerably from region to region. The figures in the "interest only" and "no interest" columns suggest

TABLE 33

REGION *and college plans for high-scoring seniors*

	Going now		*Going later*		*Interest only*		*No interest*		*Miscel-laneous*	
Region	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*	*Boys*	*Girls*
West	47%	47%	35%	25%	3%	5%	8%	12%	7%	11%
Northeast	53	44	25	15	4	8	11	20	7	13
Central	41	35	35	24	4	9	11	21	9	11
South	50	48	33	19	3	8	7	15	7	10
All regions—average	47%	42%	31%	20%	4%	8%	10%	18%	8%	12%

that the waste of talent among girls is approximately twice as great as it is among boys.[5]

It is possible to use the statistics of the National Study of High School Students and Their Plans to estimate how many students of high ability in the country plan to go to college, how many would like to go but will be prevented from doing so, and how many have no motivation for higher education. Such estimates are presented in Table 34. The United States Office of Education received reports that in 1954–55 there were approximately 1.3 million seniors enrolled in public secondary schools throughout the nation. To correct for possible duplication, the Office of Education estimated the total at 1,265,000. The first row of Table 34 shows our estimate of the number of seniors in public secondary schools in each region. The figures in the second row represent our estimate of the number in these schools in each region in the top 30 per cent of ability. Then by applying the percentages found in Table 33 we can estimate the numbers of high ability students in each region who fall in the "going now," "going later," and other categories with respect to college plans used throughout this chapter. These figures are given in the third through seventh rows of Table 34.

TABLE 34

ESTIMATED REGIONAL AND NATIONAL TOTALS *of high ability seniors, with subtotals by their college plans, among all U. S. public high school seniors, 1954–55*[a]

	West	*Northeast*	*Central*	*South*	*Nation*
Public high school seniors (estimated)	155,000	340,000	402,000	368,000	1,265,000
High ability seniors[b]	55,000	115,000	120,000	75,000	365,000
Going to college now	25,500	55,500	45,500	36,500	163,000
Going later	16,500	23,000	35,500	20,000	95,000
Interest only	2,500	7,000	8,000	4,000	21,500
No interest	5,500	18,000	19,000	8,000	50,500
Miscellaneous	5,000	11,500	12,000	6,500	35,000

[a] Figures have been rounded off to the nearest 500.

[b] Seniors in approximately the top 30 per cent in ability as defined by the performance of the sample of seniors who took the National Study test.

Several additional steps are necessary in order to estimate the annual loss from high school to college of able high school seniors who would go to college if offered scholarships. First of all, we must take into account the "interest only" category, those students who say they would really like to go to college but think they will do something other than continue their education. These are the students who, as far as we can determine from the questionnaire, are well motivated for college but never expect to get there. Constituting approximately 6 per cent of the high ability group, they number 21,500. In addition, there are those with deferred college plans. Based on the questionnaire results, and not shown separately in the figures given in Table 34, an estimated 23,000 with high ability would really like to go to college full time immediately after graduation but will have to defer college studies, principally to go to work. A third group consists of those who plan to work full time and attempt to go to college at night. This group is also not separately represented in the table. They number about 6,000. Although some of the students in this category may succeed in getting through college, presumably they stand in need of financial support. These three categories total approximately 50,000.

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[5] The combined 8 per cent showing "interest only" and 18 per cent "no interest" represents a greater waste of talent among girls nationally than Berdie found for Minnesota. See Berdie, *After High School–What?*, p. 59.

Another subgroup that might go to college if offered scholarships, and one more difficult to estimate, consists of those who plan to attend college but who will not actually do so for one reason or another. Of course, there is no way for seniors to know what unforeseen events may occur to thwart their plans; all that we can do is guess how many such disappointed graduates there may be. In Ralph Berdie's follow-up study of Minnesota high school students one year after graduation it was discovered that 74 per cent of those who planned on attending college actually did so. Partially offsetting this, some of those who originally planned on working went to college instead.[6] The Minnesota experience may not be representative, however, since it embraced all students, rather than only those of high ability. It seems safe to say that at least 5,000 and at most 40,000 of the 163,000 with high ability who plan to go to college without delay will not realize their plans. Finally, some of those in the "miscellaneous" category in Table 34 are probably interested enough in going to college but lack financial means to go. Combining the 50,000 from the last paragraph with the 5,000 to 40,000 above, we estimate that the total annual loss that might be recovered by financial aid of able public high school seniors amounts to between 55,000 and 90,000.

But to derive an estimate for the total school population lost to higher education because of financial need, we must add a figure representing the loss of those graduating from independent secondary schools. At the present time, approximately 10 per cent of the total secondary school senior population is enrolled in independent schools. Assuming that similar conditions hold for this group and that high ability is found in about the same proportion in private as in public schools, we might add between 5,000 and 10,000. This would bring the annual total of high ability seniors who do not go on to college and who presumably are in need of financial support if they are to be salvaged for higher education to somewhere between 60,000 and 100,000.

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[6] Berdie, *op. cit.*, p. 57, 195.

On the basis of the National Study findings we can also estimate the annual loss of high ability seniors that scholarship aid would presumably not recover. The "no interest" group, those public high school seniors of high ability who say they would really like to do something other than continue their education, make up 13.5 per cent of the total. This amounts to approximately 50,500. In addition, about 10 per cent of the high-scoring seniors in our sample could not be classified because of the nature of their responses or because they failed to respond, and hence in at least some cases probably have no motivation for college. The size of this group is 35,000. Adding all 35,000 and also certain non-college-going students from independent schools, we estimate that there are approximately 100,000 able high school seniors uninterested in college whose intellectual resources could probably not be salvaged for higher education simply by the offer of a scholarship.[7]

The figures presented here only scratch the surface of the mass of information that could be made available through the data collected in the National Study of High School Students and Their Plans. Follow-up studies and additional analyses should be undertaken. Various subgroups in the study's student population should be examined in detail. The relation of the characteristics of the schools in the sample and their communities to interest in college is a subject particularly worthy of study. Certain of these studies are now under way at the Educational Testing Service.

Several most significant conclusions can be drawn from these figures yielded by the study. There is a striking amount of economic and cultural determinism connected with college-going. There is a pressing need for more scholarships to tap some of the loss of high ability from high school to college. Today's able high school graduate is interested more than ever before in our history in continuing his formal education. He considers higher education essential for the work he intends to do. He is alert to many of the economic opportunities which these prosperous times afford. He is sensitive to the financial incentives around him, even to the extent sometimes of giving up his major academic interest if a scholarship is involved. At the same time, he lacks sufficient high school guidance, particularly about scholarship awards, with which to shape his college and financial plans.

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[7] One of the reasons why such estimates are difficult to make is that some of the seniors in our sample who reported no interest for college on one question indicated willingness to accept a scholarship on another. Consequently, some of this group may be more salvageable than we think.

Despite the increased interest in the bachelor of arts degree, higher education is still losing up to one-half of the top 30 per cent or so of the nation's high school seniors. Each year, apparently, between 60,000 and 100,000 highly able secondary school graduates with aptitude and interest for college fail to continue their education for financial reasons. Another group of similar size and ability lack the interest or motivation for college. This is a serious waste of intellectual resources which should not be overshadowed by the rising tide of college enrollments. In the following chapter we shall give some consideration to the use of scholarships as a means of conserving these intellectual resources.

The use of scholarships to encourage the production of scientists

So far we have attempted to show the importance to our modern economy of trained scientists. We have discussed their probable shortage in the coming decades. The loss of high ability students in transition from high school to college has been outlined. We have suggested a number of deterrents to the production of scientists and have considered some of the factors which can or do encourage the best use of our intellectual resources. We have reported on the National Study of High School Students and Their Plans and, on the basis of its results, have estimated that in 1955 there were between 60,000 and 100,000 high school graduates of college ability who failed to enroll in college for financial reasons, and another 100,000 who have high ability but who lack any interest in higher education.

In this chapter we shall examine the special case of scholarships both as a way to salvage and encourage talent in general and as a method to attract more intellectually superior persons into the scientific professions. Our use of the term scholarship is specifically limited to mean a substantial, non-returnable financial award granted a student to help him meet the costs of his undergraduate education. Other financial aids such as loans, token payments of less than 50 dollars a year, employment arrangements, prizes, and the like are excluded from this definition.

The use of scholarship aid to encourage able individuals to continue their education is increasing in popularity. Colleges and universities have long devoted a portion of their general income to the aid of the needy student. Alumni and other friends of education frequently make bequests setting up scholarships with specific prerequisites. Since the end of World War II, corporations, fraternal and religious organizations, and labor unions have stepped up their expenditures for scholarships. One of the most notable new scholarship plans to be instituted is the National Merit Scholarship program. Undoubtedly other programs providing financial aid for deserving students will be set up in the future. In 1955 over 35 million dollars was available for scholarships in colleges while another 10 million was spent by corporations and foundations sending selected individuals to college. Approximately 10 million dollars was available in various state scholarship programs in 1955, 4,650,000 dollars being spent by one state, New York. The amount spent on loans, employment arrangements, tuition rebates, and by the federal government raises the total to an impressive figure. Today, probably between one-fifth and one-quarter of the nation's undergraduates are receiving some kind of financial aid. However, about one-quarter of all scholarships are restricted to students in scientific and engineering fields.[1]

The device of scholarship aid has long been popular in America. It has generally been considered a noble type of philanthropy, reflecting a sympathy for the underdog, recognition of the value of education, and the willingness to risk one's capital in a sound investment. It has symbolized the effort in our past to equalize opportunity. In a free enterprise society, a scholarship program is the most acceptable method of influencing manpower uses. In a nation which abhors controls and is immune to most preaching and propaganda, the "market incentive" of scholarship aid to attract individuals to college and divert their energies into certain channels has had a particular appeal.

The administration of scholarship programs in the past has been varied and in some cases open to criticism. Apparent in them have been many inconsistencies, deplorable abuses, and considerable overlapping and competition among the colleges. Awards for talent other than intellectual, and selection by widely different standards—some based on favoritism and discrimination—formerly characterized many scholarship awards. Any organization considering the initiation and operation of scholarship aid should be thoroughly apprised of the weaknesses of some of the programs which originated in the past.

Despite some continuing defects, scholarship criteria have improved considerably. Fewer "athletic" scholarships are awarded today than were granted a generation ago. The number of general scholarships which impose no restrictions on the recipient is increasing. Arrangements such as those provided by the College Scholarship Service, in which over 120 colleges are cooperating to eliminate waste in the size of scholarship awards and duplication of scholarship applications, are serving to bring some order into a chaotic area.

Furthermore, scholarships continue to be the fairest means of equalizing educational opportunity. Scholarships have advantages which other types of financial aid do not possess. For instance, undergraduate loans totaling some

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[1] For conflicting estimates on this figure, see National Manpower Council, *Student Deferment and National Manpower Policy*, p. 71; Havemann and West, *They Went to College*, p. 208. See also Wilkens, *Scholarships and Fellowships Available at Institutions of Higher Education*, United States Department of Health, Education, and Welfare, Office of Education, Bulletin No. 16, pp. 163–220.

50 million dollars are available in the United States. But when loans are used instead of scholarship funds, they can shackle undergraduates with heavy financial obligations which, especially in the case of those studying for professional careers, cannot be paid off for many years. They can stifle the very initiative they were supposed to encourage, can be costly and difficult to administer, and can sometimes create more ill will than they are worth. Although some institutions like the Massachusetts Institute of Technology have successful loan programs in operation, the consensus among educators is that loans can best serve as a supplement to direct financial aid. Student employment provisions, another way of assisting a needy student, have only limited effectiveness when compared with scholarship aid. Part-time jobs, particularly for college freshmen, should be limited so that working hours do not handicap study and adjustment to college. All things considered, scholarships appear to be the most sensible way for a corporation, foundation, or governmental agency to assist needy young people in college.

Although the supply of scholarships available to college students continues to increase, the demand for this aid is still far greater. It has been estimated, for instance, that about one-third of the freshmen who entered private colleges in 1955 needed financial help. As we saw in a previous chapter, there are many estimates of the percentage of America's college-age youth who are prevented from going to college for financial reasons. Five years ago Buell Gallagher, president of the College of the City of New York, estimated that about half of those with ability and interest for college who did not go to college were blocked by financial barriers. In a recent study of California students within commuting areas of public colleges, it was reported that one-quarter of those qualified to attend college were financially unable to continue their education while about 15 per cent of the group of students highest in ability could not afford to go on with their schooling.[2] Ralph Berdie, in his study of Minnesota high school students, reported that about 58 per cent of those with high ability planning to work after graduating would go to college if they had more money.[3] In the National Study of High School Students and Their Plans, 12 per cent of those seniors with ability for college indicated that if they did not continue their education, it would be primarily for financial reasons. Almost half of the top 30 per cent of the seniors reported that expenses would be an important reason why they might not get to college.

The financial barrier continues to be great in the field of graduate work. In 1952 it was discovered that about 3,000 college seniors who had a real interest in science and were considered capable of doctorate work in their fields could not continue their studies because of their poor financial picture.[4] It has been estimated that only 36 per cent of graduate students in science pay their own way for full-time study and that an additional 14 per cent are on fellowships. The other half are earning their way.[5] M. H. Trytten has estimated that fully one-quarter of those competent enough to enter graduate school are unable to do so due to lack of financial support.[6]

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[2] Mitchell, "State Scholarships for Superior Students," *California Journal of Secondary Education*, vol. 25, Dec., 1950, p. 490.

[3] Berdie, *After High School–What?*, p. 17, 69, 142.

Statistics on the distribution of income for families in this country corroborate these gloomy percentages. In 1950, 21 per cent of the nation's family units received less than 2,000 dollars a year in money income before taxes; 16 per cent received incomes between 2,000 to 2,999 dollars; 19 per cent between 3,000 and 3,999 dollars; and 14 per cent between 4,000 and 4,999 dollars. Only 30 per cent of the family units had incomes greater than 5,000 dollars a year.[7] In his book, *Financing Higher Education in the United States*, John Millett declares that an income of at least 5,000 dollars was needed to enable a family to send one child to college in the 1950's.[8] By that token, one can conclude that the children in seven families out of every 10 face serious financial barriers in attempting to acquire a college education.

Furthermore, the relative cost of attending college has increased so rapidly that, apart from inequalities among economic groups, there is an overall need for financial support if we are to prevent private education from being priced out of existence. Many private institutions have raised student charges in recent years. In addition, at least 24 state universities have raised their resident and nonresident tuitions and fees in the last two years. As the cost of higher education continues to climb, our supply of scholarships will become more and more inadequate.

As we have seen, lack of financial support is not the only reason why many capable youth do not go to college. Indeed, lack of motivation for college may well be a more important factor in accounting for the loss of talented students from high school to college than finances. Certainly, if we consider the federal government's experience after World War II in granting tuition and subsistence allowances to veterans who went to school, it is worth noting that only about one-fifth would not have attended college had they not received assistance under the G.I. Bill.[9] In 1954 only about 250,000 of the three million veterans discharged since the outbreak of the Korean War were attending college.[10] However, there does not appear to be a clear-cut line between lack of motivation and lack of funds. Interest in higher education can be kindled by the prospect of financial aid.

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[4] American Association for the Advancement of Science, *Proceedings of the Second Conference on Scientific Manpower*, p. 22.

[5] Meyerhoff, "Arms and Manpower," *Bulletin of the Atomic Scientists*, vol. X, no. 4 (April, 1954), p. 120.

[6] Trytten, "Present Resources and Public Policy," in Wolfle *et al.*, *Human Resources; The Needs and the Supply*, p. 61.

[7] United States Department of Commerce, Bureau of the Census, *Income of Families and Persons in the United States*, 1950 series, no 9, p. 60; Wolfle, *America's Resources of Specialized Talent*, p. 155. In 1955 the Commerce Department estimated that about 40 per cent of all families had incomes exceeding 5,000 dollars a year, according to *The New York Times*, March 23, 1955. See also United States Department of Commerce, *Income Distribution in the United States, 1950–1953*.

[8] Millett, *Financing Higher Education in the United States*, p. 363.

There are a number of desirable features which should be incorporated in any scholarship program to make it as educationally sound as possible. Selection of scholarship winners should be made objectively on the basis of ability, achievement, and promise. There should be no discrimination in selection on the basis of race or creed. The scholarship holder should be permitted to study in any field. The size of the scholarship should be set according to need. The award should be for the duration of the scholar's undergraduate study subject to satisfactory academic progress. Financial aid to students should be accompanied by sound financial and educational guidance. There are two additional desiderata that should be included in scholarship plans sponsored by corporations, foundations, and other organizations. These are that the recipient of financial aid should be given freedom of choice in selecting his college and a supplementary grant should be given to the institution which the scholarship holder attends to help pay for the cost of his education. In the opinion of most educators, the best scholarship program is one that encourages talent in general. The fewer the restrictions the better.[11]

What about federal scholarship aid, either for the talented in general or for those in certain specialized fields? It is worth noting that since the end of World War II the bulk of informed, competent sentiment has been in favor of federal scholarship aid. In his book, *Science, The Endless Frontier,* Vannevar Bush gave high praise to the program proposed by the Moe Committee which would have awarded 6,000 undergraduate scholarships and 300 graduate fellowships yearly at an annual cost of 30 million dollars when in full operation.[12] In 1945, in testimony before a subcommittee of the Senate Committee on Military Affairs, Dr. Bush asserted, "There is no more important part of the proposal before you than that calling for award of scholarships and fellowships for higher education in science. . . . We cannot depend upon the accidents of birth and fortune to supply the trained scientists essential to our national welfare and security."[13] A year later, in a speech on the floor of the Senate, Senator Kilgore called scholarships "highly essential" and proposed that Congress "subsidize the crop of young scientists in this country."[14] The President's Commission on Higher Education in 1947 gave highest priority to its recommendation for a nation-wide system of grants-in-aid for 20 per cent of the undergraduate population.[15] General Hershey's Scientific Advisory Committees, the Hoover Commission, the Federal Security Agency, and numerous nongovernmental organizations have favored a general program of federal scholarships.[16]

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[9] *Ibid.,* p. 56.

[10] *The New York Times,* October 24, 1954.

[11] For additional comment on this subject, see Cole, *Sponsored Scholarships.* Some of the growing literature on scholarships is summarized in Bureau of Applied Social Research, Columbia University, *Selective Bibliography on the Role of Scholarships in American Undergraduate Education.*

[12] Bush, *Science, the Endless Frontier,* p. 64.

Scientists themselves have gone on record as advocating the expenditure of federal funds for undergraduate scholarships. In one survey, over 60 per cent of those scientists surveyed were in favor of such awards. The National Education Association questioned leaders in higher education in 1949 and discovered in replies from almost 1,000 institutions that over 80 per cent were in favor of federally financed scholarships.[17] Many other educational authorities have strongly urged the establishment of some sort of federal scholarship program.[18] More recently, and at the state level, a report sponsored by the California State Department of Education and the University of California recommended the establishment in that state of 2,000 undergraduate and 500 graduate awards yearly to decrease the loss of students from high school to college.[19] There is clearly strong justification for more scholarship aid and for federal and state expenditures in this field.

There is considerable doubt in the minds of many informed persons as to whether any large-scale, federally supported scholarship plan should be restricted to particular fields of study. In discussing this idea with educators, I was impressed by the overwhelming majority who favored a program that would support general ability rather than an ability in the sciences alone. They preferred a program that would not recruit high school graduates for specific, specialized professions but would tackle the problem of financial aid to deserving youth on a comprehensive rather than a piecemeal basis.

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[13] United States Congress, Senate, 79th Congress, 1st Session, *Hearings on Science Legislation, Hearings before a Subcommittee of the Senate Committee on Military Affairs*, vol. XXI, p. 201.

[14] *Congressional Record*, July 1, 1946, p. 8,029.

[15] United States President's Commission on Higher Education, *Higher Education for American Democracy*, vol. II, pp. 51–55.

[16] See also Quattlebaum, *Federal Educational Activities and Educational Issues before Congress*, vol. I, p. 14; Trytten, *Student Deferment in Selective Service*, p. 90.

[17] Axt, *The Federal Government and Financing Higher Education*, p. 214.

[18] See, for instance, Warner, Havighurst, and Loeb, *Who Shall Be Educated?*, p. 165; Lee, "Government and Educational Mobility in a Democracy," *The Harvard Educational Review*, vol. 23, no. 3 (summer, 1953), p. 216; Hollinshead, *Who Should Go to College*, p. 83.

[19] Mitchell, "State Scholarships for Superior Students," *California Journal of Secondary Education*," vol. 25, Dec., 1954, p. 489.

The principle of selective scholarships has many drawbacks. Many who object echo the words of the Steelman report:

> "It would be a serious mistake, however, to establish a scholarship or fellowship program in the physical and biological sciences alone. What we require as a nation is to extend educational opportunities to all able young people, leaving it to them to determine the field of study they desire to pursue. In normal times, freedom of choice must be allowed to operate in education, as well as elsewhere, if we are to preserve our free institutions. No agency of the government is sufficiently far-seeing—nor ever likely to be—to foretell 15 or 20 years in advance the fields in which we shall most need trained people. In free competition, the physical and biological sciences will get their share."[20]

More recently, Dael Wolfle has pointed out that it would be more desirable to have our trained, talented people in fields they had chosen freely and that serious imbalances might occur if a powerful agency upset the traditional mechanism in society for adjusting the supply to changing demands by offering many scholarships available only to students in certain specialized areas. In his opinion, betting on brains is preferable to betting on particular fields. Since demands will change in the future he thinks it best to let each student specialize freely in order to insure as much intellectual flexibility as possible.[21]

There is a deep-rooted rationale for such a position that must be dealt with in devising any scholarship recruitment program. To what extent, however, must we override our traditional reliance on freedom of choice, or the right to be wrong, in order to supply our pressing needs, to create more scientists and engineers, and to save our necks? David Riesman has stated this position in these words:

> "Men should not be forced by the needs of society to give more than conditional cooperation to specific short-term goals. Thus, I think we can ask people to be vaccinated, but not to believe in its efficacy, or in science, or in long life. And on the whole I prefer that we win people's cooperation by offering concrete advantages—including such personal growth as they may gain from the cooperation itself—without asking them what their fundamental values are."[22]

But endorsing this approach does not necessarily mean completely rejecting financial incentives as a means of attracting more persons into certain fields. Putting a premium on individuals able and willing enough to train themselves for more advanced contributions to society can be accomplished without losing our precious freedom of choice. There is a middle way between chaos and strict controls. Although it may be unrealistic and unwise to run a scholarship program for the study of science only, there is validity in selecting students for college studies leading to careers in science while still granting the students a freedom of choice once they are launched on that study.

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[20] Steelman, *Science and Public Policy*, vol. I, pp. 35–36.

[21] Wolfle, *America's Resources of Specialized Talent*, p. 266.

[22] Riesman, *Individualism Reconsidered*, p. 18.

There are a number of arguments that can be offered in defense of this middle way. First, a program designed to encourage students to study for science and engineering careers which placed no restrictions on what they studied would not be subject to criticism for overemphasizing a particular field to the detriment of other areas of intellectual endeavor.[23] The major government reports in the past dealing with the education of scientific manpower have emphasized the need for assisting students in all fields of knowledge. Scholarships by themselves cannot create new talent. However, their existence tends to channel existing talent in particular directions. If we emphasize science and scientific careers in this fashion, we must be willing to pay the price involved—that is, the consequent neglect of some other area of human intellectual enterprise.[24]

Another reason why a science scholarship plan that imposed no restrictions on the recipients would be better than one in which the primary purpose would be to recruit scientists is that few boys or girls of 17 or 18 would seem ready or able to make the sort of commitment implied in accepting a sizable four-year award for specified study. Vocational decisions should not be made before students are ready to make them. As Warren Johnson has pointed out, a scholarship program, like an advertising campaign, is an "artificial stimulation" and may attract students to a particular program of study in science who later will find that their primary interests are not there at all.[25] Quality must not be sacrificed for quantity. Recruiting for science students must be supplemented by realistic guidance and tempered by educational wisdom. It is unwise, educationally, to shackle a scholarship recipient to a particular program of study. It is known that about half the nation's college youth make a change in their vocational objectives between college entrance and graduation. If a scholarship student faces the loss of financial support should he change his major subject, he may be forced to study a particular field in order to stay in college, even though he discovers that his interests or aptitudes are changing. This would be detrimental for the student and for the nation.

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[23] As has been pointed but by Axt, in *The Federal Government and Financing Higher Education*, p. 233, 235, existing federal policy has emphasized the natural sciences so heavily that more support for this field alone should be accompanied by a general program of aid to individuals, regardless of their specializations.

[24] For additional consideration of this point, see Wrenn, "High Level Research Talent," in National Research Council, *Human Resources and the Fields of Higher Learning*, p. 44.

[25] American Association for the Advancement of Science, *Proceedings of the Second Conference on Scientific Manpower*, pp. 34–35.

The fact that two-thirds of the scholarships now awarded by business, industry, foundations, and other organizations are limited to a specific field of study, and that the largest number of them are in science and engineering, is all the more reason why future awards should not be so restrictive.[26] Despite the refinements of aptitude testing, the results of educational processes are frequently unpredictable. Once launched in four years of study in which he will discover new universes of learning, wider horizons, and new career possibilities, the serious, capable scholarship student should be given free rein to choose the field in which he can make the freest, fullest, and most productive use of his abilities, even when the federal government finances his education.

The ideal science scholarship program would provide for the following things. First, early identification and encouragement of real talent in general, with excellence or potential excellence in mathematics and science as important but not exclusive factors. Second, no restriction on occupational choice as long as the occupation selected reasonably fitted the scholar's interests and aptitudes. Third, positive, continuing guidance of the talented youth from the tenth-grade level through his college years. Fourth, sizable financial encouragement of the most able when there is a financial need. By this I mean primarily support of those students who lack 1,000 dollars or more a year for their basic college expenses, rather than those who need only a few hundred.

There are some people who oppose the idea of scholarships supported by the federal government on the grounds that this is an unwarranted extension of governmental operations. Actually, the question of federal governmental activity as a principle need not necessarily be involved. In purely pragmatic terms, if we in our society accept government price supports for farm commodities, if we spend public money on migrant birds, should we not recognize the greater need for the conservation of human resources by aiding those needy, able students who want and ought to go to college?

Another justification for scholarships supported by the government is the existence of some 300 federal educational programs.[27] The Bureau of Wild Life and Fisheries spends money to encourage students to study fishery technology and to inform them of opportunities in the fisheries; the Immigration and Naturalization Service promotes citizenship education; the Civil Aeronautics Administration encourages aviation education; the Federal Security

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[26] See Cole, *Sponsored Scholarships*, p. 11.

[27] Bureau of Applied Social Research, *The Role of Scholarships in American Undergraduate Education. A Proposal for Research* (mimeo), p. 15; Quattlebaum, *Federal Educational Activities and Educational Issues Before Congress*, vol. II, p. 9.

Agency supports education in food conservation; and the United States Navy employs a scholarship attraction to recruit candidates for its NROTC units. Why shouldn't the federal government allot scholarships in a conservation program aimed at salvaging our young scientific talent? Indeed, with so many pressures at work to disturb the normal distribution of intellectual resources, perhaps a pressure by the government is needed to insure that the field of science continues to get its share. But by the same token, pressure should also be exerted by those groups whose responsibility is in the fields of the humanities.[28]

Whether we like it or not, a revolution is occurring in the nature and function of scientific endeavor that has direct bearing on the advisability of a federal scholarship program. The nineteenth and twentieth centuries have witnessed a tremendous extension of the powers and responsibilities of national governments in the area of economic and social affairs. In our time we are witnessing a similar expansion of the government's responsibility in the area of science. In order for the nation to survive, the government is obliged to take a hand in the financing and coordinating of scientific activity. The upheaval in scientific endeavor has been a dual one—from the more peaceful type of basic research to a more warlike type of applied research—and from private philanthropic subsidy to government-dominated support and direction.[29]

In this connection, in his press conference on November 9, 1954, President Eisenhower alluded as follows to the use of federal scholarships to encourage students to study science:

"Question: Sir, along those same lines of education, there has been a survey or series of surveys lately that said that the Soviet Union's output of science students has been vastly increasing in quality and in quantity, and that our own output of students who are interested in science seems to be on a dangerous downtrend, continuously decreasing. Have you any thoughts on the part of the government in that sense?

"Answer: Well, he believed that here was one place where people in government should be very alert, and if there was found anything like that, there were numbers of ways open to us to correct the situation without waiting for the economic influences to do it.

"We knew this: If you got few enough scientists, they could command prices that you would have a rush to the scientific colleges, but we couldn't wait for that, so he believed the federal government could establish scholarships.

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[28] For some considerations of this issue, see Allen, *The Federal Government and Education*, p. 37, 87, 112, 154. Axt, *The Federal Government and Financing Higher Education*, pp. 233–259, contains an account of the growth of a federal scholarship policy. Also useful are Quattlebaum, *op. cit.*, vol. II, p. 13, 53, 78, 114, 183; Russell, *Federal Activities in Higher Education After the Second World War*, and Millett, *Financing Higher Education in the United States*, pp. 432–442.

[29] See Haslett, *Science in Transition*, p. 232.

"He would not want the federal government to go in and support a particular college or university, and then say, 'Now, go there,' but it could support scholarships which could be used at any outstanding university, and in a number of ways which could encourage this kind of education, and possibly—he hasn't talked lately to any of his scientific friends on this subject, and he was just saying what could be done and, possibly, would have to be done. He didn't know."[30]

If we look to Europe we find several examples of nations that have embarked on programs of scholarship aid. The controls and incentives employed by the Soviet Union to increase her supply of technically trained personnel have been described sufficiently elsewhere. Among the nations of the free world, Great Britain has succeeded effectively in an attempt to reach equality of opportunity in higher education. Approximately 72.8 per cent of England's full-time students received financial assistance in the academic year 1949–50, and the Ministry of Education plans to support at least 60 per cent of the national student body during the present decade. Moreover, the English even accept the proposition that the value of a scholarship should vary not only with individual need but with the course of study selected.[31] Recently France announced the establishment of 1,000 scholarships for the study of science.[32]

Another justification for federal scholarships might be found in the partial failure of our programs of graduate fellowships to accomplish their job. Despite the many fellowships now available in the sciences, there are not as many applicants as there should be, primarily because so many potential candidates have left college before graduation. Since the present graduate-level programs are proving less effective than had been hoped, future investment at the undergraduate level may well be a sounder approach to the shortage of scientific talent. It is also worthy of note that additional graduate fellowships would intensify the shortage of university assistants and instructors now plaguing many campuses. If society is willing to stimulate science in offering pecuniary incentives at the graduate level, similar incentives to encourage undergraduate attendance in college should be offered to high school graduates.[33]

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[30] *The New York Times*, November 10, 1954.

[31] Dodds, Hacker, and Rogers, *Government Assistance to Universities in Great Britain*, p. 9, 11, 31, 33, 35; Goetsch, *Parental Income and College Opportunities*, pp. 121–128.

[32] For details on the French scholarship program see *L'Education Nationale*, Jan. 13, 1955, pp. 5–6; *Association Internationale des Universités Bulletin*, vol. II, no. 3 (August, 1954), pp. 189–192; vol. II, no. 4 (November, 1954), pp. 254–256.

[33] For additional discussion of this point, see Wolfle, "Intellectual Resources," *Scientific American*, vol. 185, no. 3 (September, 1951), pp. 42–46; Hollinshead, *Who Should Go to College*, p. 65.

In securing approval of a federally supported scholarship program in the sciences there are a number of problems to be faced. First, the idea of federal sponsorship must be accepted by the public. There are those who object to the identification and support of a select group by the government, no matter how democratic the operation may be. The ghost of Horatio Alger still haunts our legislative halls; the myth is still strong that any really talented fellow with enough initiative can get ahead in the world if he will only work hard enough. But many capable youngsters come from economic, social, and educational environments that smother any spark of inventive initiative.

A second question that must be considered relates to the potential siphoning off of persons from non-science areas into science careers through the use of scholarship funds. How great a danger is there that this will take place? We have estimated that annually about 200,000 high ability high school seniors do not go on to college. Suppose for this example that all of them would go if offered a scholarship. Let us further assume that approximately 150,000 of them are not interested in science. Then, on the basis of the statistics revealed in our National Study of High School Students and Their Plans, it seems safe to estimate that about half of them would switch to science study if offered a scholarship to do so. About 75,000 would be in this category. Let us further estimate that in any science scholarship plan, at worst, about half the scholarships awarded would go to students with an interest in science and about half to students with a primary interest in non-science fields. Then suppose there were a science scholarship program granting 1,500 awards yearly, 750 of which would be won by persons primarily interested in non-science areas. Only about 1 per cent of this group of 75,000 would be affected.

On the other hand, looked upon as a solution to the current shortage of scientists, such a scholarship program would provide material assistance toward the conservation of intellectual resources. Since at the very least there are approximately 15,000 high ability high school graduates with interest and aptitude in the sciences who cannot go to college for financial reasons, then awarding 1,500 scholarships would reach 10 per cent of the potential. Fifteen hundred science scholarships, therefore, should salvage 10 per cent of the current scientific talent loss with the danger of a 1 per cent drain from other fields. Three thousand scholarships should attract 20 per cent of the potential supply with the danger of a 2 per cent siphoning from non-science areas. Recruitment in this fashion can be viewed as a calculated risk. A sliding scale can be drawn on which to chart the potential increase in science students against the potential risk of overemphasizing science to the detriment of other subjects.

A third question that must be faced in considering federal sponsorship concerns the many procedural problems connected with the operation of any scholarship program, whether it is sponsored by the government or by a private organization. The process of selecting candidates, the type of testing to be undertaken in order to identify the best candidates, the handling of payments to the winners, the measurement of the recipients' financial need—all of these require careful, expert attention. With respect to one of these problems—determining a scholarship candidate's financial need—the accuracy, precision, and fairness of need estimation has been greatly facilitated by procedures developed by the College Scholarship Service.

An important problem in the selection process of any scholarship program is the question of how to identify the student of high ability whose interests or personality have prevented him from coming to the attention of his teachers by achieving high grades. High grades and high intelligence do not always go hand in hand. Indeed, only half of those students whose mental ability places them in the top tenth of their age group stand academically in the top fifth of their high school class.[34] Some gifted children care little about the traditional academic requirements and, wisely or not, refuse to jump over the orthodox scholastic hurdles held out by school authorities. Primarily procedural problems such as these, however, can be tackled with some hope of success once the principle of federal scholarship aid has been accepted.

A final point might well be raised. Granted that we wish to increase the number of capable young persons entering science and technological careers, offering financial support to just those who will major in science need not be the only course to follow. There are many ways to contribute to the welfare of science. Helping to produce researchers in chemistry, aeronautical engineers, high school teachers, and inventors of cadmium bombs are some of the most obvious ways. But science may be just as importantly served by a statistician or sociologist who devises a new application of physical laws to society, by a writer who can transform the mysteries of atomic physics into a meaningful concept for the semi-illiterates of the world, by a statesman who weans ugly politics out of the trough of emotionalism into a more reasoned climate, or by a poet who bridges the gap between the different tongues of the different professions. The lifeblood of science and technology must flow in the veins of all the nation. Encouragement of those who may contribute effectively to science years hence may mean support of many more than just those training for careers in a research laboratory.

By the same token, efforts to encourage the study of science in our schools and colleges serve to help all specialized areas, scientific and nonscientific alike. The future lawyer, historian, business executive, and statesman will be the better educated if his schooling has included a certain amount of mathematics and science. Emphasis on science courses, therefore, can help other members of society as well as future scientists.

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[34] See Wolfle, *America's Resources of Specialized Talent*, p. 316.

To summarize, America's current and predicted shortages in the scientific professions call for a conservation program to utilize the nation's intellectual resources to the fullest. One point at which such a conservation program appears to be most needed is at the twelfth-grade level when, for financial and other reasons, 50 per cent of the high school graduates with high ability fail to enter college. One form which such a conservation effort might take is a scholarship program. The best type of scholarship plan, especially on a nationwide basis, is an across-the-board program that encourages intellectual talent in general. If a scholarship program of narrower design concerned with a specific field such as science is chosen, it should carry as few restrictions as possible.

One hundred thousand scholarships are needed immediately if we are to salvage our loss of talent from high school to college. The colleges cannot do the task alone. Government and industry should be partners, cooperating with schools and colleges in a 200 million dollar investment in the nation's intellectual resources—that is, in its 17 and 18-year-olds of high ability. The crisis we face in meeting our shortages of trained scientists, engineers, teachers, and other specialists is such that some sort of undergraduate scholarship program sponsored by the federal government is urgently needed. Whatever means can be employed to provide additional scholarships should be used. In this connection, it is sobering to recall deKiewiet's observation that in our society, "It is easier to assign a portion of our income to digging oil wells than to stimulating a greater flow of our underdeveloped intellectual resources."[35]

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[35] American Association for the Advancement of Science, *Proceedings of the Second Conference on Scientific Manpower*, p. 18.

Conclusions and recommendations

We set out in this study to find answers to several questions. We have endeavored to discover how many talented youths, and among them how many capable science students, do not go on from high school to college. We have attempted to find out what inducements might attract more of these able young people who have clear-cut scientific aptitudes to college and into science careers. We have tried to estimate what effect the offering of various inducements to college and science careers would have on the supply of scientifically trained individuals. We have reviewed the problems involved in instituting and operating undergraduate scholarship programs and have attempted to estimate the number of additional scholarships currently needed. We have tried to bring together in this report whatever pertinent information we could find on the subject of scientific ability, its characteristics and identification, its supply and demand, and the factors at work in the nation that encourage or discourage the production of scientists and engineers. We have secured answers to a questionnaire on college plans, science interests, and financial needs from a 5 per cent sample of public high school seniors. While we have uncovered some of the answers we sought, others have eluded us and, in inevitable fashion, we have probably raised more questions than we have settled.

In summarizing our results, it is evident that the United States is wasting its intellectual resources at the rate of approximately 200,000 18-year-olds a year. These are the young people with college ability who terminate their education upon graduation from high school. Apparently, between 60,000 and 100,000 highly able high school graduates with aptitude and interest for college fail to continue with their education for financial reasons. Another group of approximately 100,000 with similar ability lack the interest or motivation for college.

Presumably about one-quarter of the 200,000 highly able young people have interests and aptitudes that would serve them well in scientific careers. Many of these, however, are probably lost to the scientific professions because they have not been stimulated or guided into taking college preparatory programs that included a minimum number of mathematics and science courses. It is probable that each year between 8,000 and 15,000 male high school graduates with marked scientific talent could be retrieved if they could be found and provided with sufficient financial aid to enable them to go to college. Furthermore, it has been suggested that the loss to science and engineering of able young women is proportionately greater than the loss of young men. If the results of the National Study of High School Students and Their Plans are correct, about half of the top 30 per cent of high school seniors really want to go to college full time but only 45 per cent expect to be able to do so; almost half of them would have preferred more mathematics and science in high school; and only one-quarter of them had much college guidance in school. Moreover, on the basis of other evidence available, it seems clear that three out of every 10 individuals with the intellectual capacities to rival our most brilliant professors and our most productive inventors fail to attend college.

Although some persons may quarrel with these figures, they appear to be sufficiently accurate to indicate several things. First, there is no single dramatic solution to the problem of how to stop wasting intellectual resources or how to increase the number of scientifically trained persons in this country. Second, some of the loss of potential scientists results from poor high school teaching, insufficient guidance, and inadequate facilities in the nation's overcrowded schools. Indeed, at the present time, one of the most serious crises the nation has ever faced is the shortage, almost the disappearance, of the competent, well-trained, stimulating high school science teacher. It is a breed that faces extinction. Third, although some able science students are deterred from entering scientific or engineering careers because of the school situation, many more are affected by deterrents outside the school. Because of these community and parental deterrents, lack of motivation appears to be one of the principal reasons why a majority of the nation's superior high school graduates fail to go on to college. Fourth, insufficient financial support appears to be the sole or primary reason why between 60,000 and 100,000 of these superior persons fail to enroll in colleges each year. The latter point has led us to conclude in our study that at least 100,000 scholarships are needed immediately in order to eliminate this loss of talent from high school to college.

While our studies have indicated a serious need for additional scholarships, we believe there are other ways of interesting capable students in science and engineering careers which merit support. These methods of inducement are not necessarily alternatives to scholarship programs but could supplement them by leading those able young people who would not be attracted to college by scholarships to continue their education. These supplementary activities would attempt to do the following:

1. Undertake more widespread early identification and encouragement of gifted students in the schools and support efforts to enrich and accelerate the elementary, secondary, and higher education of the gifted.

2. Enable the individual to make an intelligent choice of occupation by providing him with the informed, directed guidance which would help him to become aware of his capabilities and limitations.

3. Supply the student with the tools which would enable him to pursue a scientific or other specialized career, that is, with adequate mathematics and science courses taught by stimulating, well-paid teachers.

4. Encourage immediate, extensive federal and state legislation to aid and improve elementary and secondary education by providing more classrooms, better facilities, and salary raises for teachers.

5. Secure a public opinion favorable to the maximum utilization of intellectual powers through an information program that would attempt to dispel the existing apathy and hostility toward intellectual attainment and scientific activity.

In order to achieve all these objectives of a comprehensive and diverse effort to encourage scientific talent, there are a number of specific activities and research projects that should be put into action. These are listed and discussed in the summary that follows.

Scholarships

Approximately 100,000 additional scholarships are needed to salvage our intellectual resources at the 18-year-old level. We recommend that institutions of higher learning, industrial corporations, civic, fraternal, labor, and religious organizations, and the federal and state governments support additional scholarship programs in a conservation program that would utilize the nation's intellectual resources more fully. An accompanying nation-wide talent search is also strongly recommended in order to identify students of high ability, encourage them to do the excellent academic work of which they are capable, and help them secure a higher education.

Teacher encouragement

1. "Recognition" fellowships should be awarded to high school teachers doing excellent teaching to encourage them to do even better work. Unlike present awards, these fellowships would not necessarily take teachers out of the classroom for an entire academic year.

2. A training program is desirable for high school science teachers who find themselves teaching science material for which they are not prepared.

3. More industrial summer work arrangements should be established to give teachers up-to-date information about progress in their fields and to provide them with additional recognition and remuneration.

4. A "retreading" program designed to attract former experienced teachers back into the profession should be undertaken. Such a program would provide the professional training necessary for them to be eligible again for teaching positions.

5. Additional efforts should be made to secure wider adoption of the use of teachers' assistants (laboratory assistants, clerks, etc.), particularly at the high school level, to permit more efficient utilization of the classroom teacher.

Aid to schools

1. Smaller high schools within convenient distance of each other should be urged to cooperate to diversify their curricula in order to offer a wider variety of mathematics and science courses within a given area. Elimination of expensive duplication of courses would be accomplished by transporting students or teachers and equipment to different schools for different courses. Increased student enrollment in science and mathematics courses and a better division of teacher labor might well result from this.

2. In large high schools, the employment of special teachers for superior students is recommended. The job of these teachers would be to teach special classes, identify the gifted, set up special programs and courses, provide special study materials, assist other teachers and the administrative staff, and work with the parents of highly able students so as to provide gifted students with every possible stimulation.

3. Whenever possible, research scientists in industry or higher education should be encouraged to serve as part-time consultants and teachers in public high schools.[1]

4. Experimental summer mathematics courses should be offered to qualified high school graduates and college freshmen with insufficient mathematical

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[1] An established precedent and model for this is suggested in the following passage: "Lawyers and doctors have for many years been accustomed to assisting in their specialties in the colleges of the country. The bases for such part-time teaching have been well set in practice and seem to be generally acceptable. It seems possible, therefore, that school principals and boards of superintendents faced with the problem of offering the essential sciences in their curricula might invite resident scientists and engineers in their communities to assist in the technical instruction on a part-time basis." Libby, "Scientific Education," *School and Society*, vol. 81, Feb. 5, 1955, p. 36.

background for college science or engineering courses. These summer courses might be combined with an experimental program to identify the potentially able in areas where a sufficient number of mathematics courses are not available in the secondary schools.

5. Continued examination should be made of the need for broader federal, state, and local financial support for the improvement of existing educational plants, to overcome the present shortage of classrooms and other educational facilities, and to provide adequate salaries for teachers.

Scientific careers for women

1. Additional efforts should be made to attract women into science and other specialized careers by providing more information, particularly at the high school and college level, about professional opportunities for women in science.

2. Industries should be encouraged to increase the number of part-time jobs available for women.

3. Refresher courses for women who have been out of the specialized labor market for some time should be instituted.

4. Consideration should be given to the establishment of more accelerated training programs to prepare women for science teaching, and also to the establishment of short courses designed for women scientists and other specialists who are at home raising families to keep them informed in their specialties and to encourage them to return to productive employment as soon as their children are grown.

5. There should be further extension of income tax benefits, in the form of more liberal child-care deductions, to encourage women to enter and remain active in scientific and other professional careers.[2]

Federal goverment policy

1. Additional consideration should be given to the extension of federal income tax benefits to enable needy students to attend college.

2. Continued systematic appraisal of the effects of national military and selective service policies on the production of scientists, engineers, and others with specialized intellectual skills is needed to insure that these policies are in the best interests of the nation.

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[2] For a detailed proposal of this nature, see Appendix A.

Informational programs

1. The production and distribution to high schools of accurate and stimulating periodicals, books, guidance materials, and documentary films on science and careers in science should be promoted and carried out.

2. Information should be distributed to elementary schools on what can be accomplished at this level to stimulate interest in science.

3. A program should be undertaken to interpret to schoolteachers and parents the process of vocational choice and the function which the school serves in this process.

4. A special information program should be directed toward schoolchildren and their families belonging to culturally and economically deprived groups in order to salvage some of the underdeveloped intellectual potential among the underprivileged.

5. A public information campaign should be supported, utilizing all media of communications to acquaint the public with the shortage of professional and scientific talent and the implications of this shortage for national defense. Advertising which popularizes the talent search and which seeks to awaken the nation-wide consciousness of the concrete value of high intellectual ability would be in order.

Research projects

1. Additional research should be undertaken on the results of the National Study of High School Students and Their Plans. This should include following-up the high-scoring seniors to ascertain to what extent they realized their college and career plans, and also a follow-up study, in 1956–57, of those tenth graders who participated in the National Study to examine changes at the senior high school level in interest in college-going and the study of science.

2. There is need for a five-year study of a number of high schools matched as to size, economic background, type of community, etc., to see what factors would account for any differences in college-going and interest in science.

3. A comparison study should be made of high schools that have high student interest in science and a high college-going percentage with high schools that do not have either to ascertain what factors might account for this difference.

4. Further evaluation is recommended of the problems, advantages, and disadvantages of acceleration, ability grouping, and special classes for the gifted in school.

5. Additional study is required to determine which factors decide college-going and influence career decisions.

6. A study of able high school and college students who do not like science in order to seek the origin, reasons, and intensity of their attitudes would be fruitful.

7. A study might also be made of college students who give up studies in engineering and science to determine their reasons for doing so and to see how much of the loss of potential scientists in college is due to lack of aptitude, changes in interests, financial difficulties, poor teaching, etc.

8. Particularly useful at the present time would be a survey of those who have left the teaching profession during the last three years to discover the reasons why they have left, the intensity of their original interest in teaching, what work they have done since leaving the profession, and what inducements including salary would attract them back to the classroom.

9. Further study should be undertaken of those factors contributing to differences in college enrollment among the states in order to determine the relative importance for college-going, within a state, of income, educational effort, vocational characteristics, and attitudes toward education.

10. The high school and college records of today's eminent scientists might profitably be examined to see how their early performance foreshadowed their future achievement.

11. Useful findings might result from a study of the "marginal man" in a group of intellectually superior persons, the man who does not perform as well as his colleagues although he is their mental equal, to discover what would enable him to perform better. This might be similar to studies made to determine why some children of superior intelligence do not make corresponding progress in school and why differences exist in productivity and creativity between persons of equal intelligence.

12. Additional consideration of programs of graduate study in American universities is needed to see if they are contributing inadvertently to the waste of intellectual resources, and if so how this is happening.

13. A survey should be made of the potentialities and limitations of convertibility among professional fields to discover to what extent professional and technical workers in one field could be attracted to another in an emergency and what effect postdoctoral training would have in increasing such personnel flexibility within and between fields.

14. Finally, a study of the development of specialism in the American economy is recommended to discover what factors have contributed most to its growth, what determines occupational distribution among the specialties

and also the extent of intelligence and training needed for various specialties, and how much of the national wealth should be siphoned off as an "intellectual capital investment" in support of specialized professional and vocational training and preprofessional liberal arts education. Such a study might provide additional information on the future demand for professional and technical workers, the past role of the talented specialist in industrial and social progress, and evolving changes in public attitudes toward research, education, and the talented individual.

It would be useful if these programs and activities could be given clear-cut priorities in terms of desirability and potential productivity. After careful examination, however, it does not seem possible at this time to ascribe an index of effectiveness to the various programs outlined. Because of the many variables involved it is difficult, if not impossible, to devise an accurate, precise formula that would indicate what a certain sum of money spent on one program would produce in the way of scientists or other specialists and compare that with the productivity of another program in terms of its cost. To cite an example, it would be possible, based on the answers given by seniors in the National Study of High School Students and Their Plans, to estimate that the addition of about 1,500 scholarships would enable approximately 300 persons to go to college who otherwise would not go and allow another 500 to go to college sooner than they normally could. But this would be doubly misleading. The awarding of these 1,500 scholarships presumably would free awards by other sponsors for other candidates and consequently a chain reaction would be started enabling other college hopefuls to get financial support. Furthermore, the award of scholarships in any one year has secondary effects on the school guidance counselors, teachers, classmates, friends, and younger brothers and sisters of the scholarship winners which will attract more people to college and perhaps to science a few years later. To speak solely of a scholarship program's current productivity is only part of the picture.

By and large, the more immediate programs are the least expensive and the least fruitful. The long-range operations are the most costly and are likely to be the most productive. One might envisage a pyramid of productivity in which inexpensive short-range programs would have little immediate effect and in which costly long-range plans attempting to raise the quality of teaching and guidance, provide an adequate educational plant and program for able children, and increase productivity and income of the entire population would yield the most in the way of additional persons for scientific and other professional careers. In the absence of any easy formula, it would appear that the wisest course would be to attack the problem of the conservation of intellectual resources on as many fronts as possible. This would mean a diversified type of investment of time, energy, and money to provide more scholarships, give greater support to teachers, and make more effort to remove the economic and cultural barriers to the development of all the nation's intellectual potential.

We shall probably discover that any long-term increase in the number of scientists our society produces will result from the "upgrading" of the population over many years. As more students continue longer in high school and college, as they go to better schools, as the economic well-being of families improves, the number able to realize their potentialities in scientific and other highly specialized careers should increase. The influence of good nutrition on the performance of persons has already been noted. The beneficial effect of certain types of environmental influences has been suggested. The financial barrier blocking the intellectual advancement of seven out of 10 families has been described. As our nation raises its standards of living, improves its diet and living conditions, raises the income of its lowest-paid classes, and abolishes discrimination against minorities, we should find a greater proportion of persons of high ability coming to the fore in the population. Any efforts, therefore, to improve the living conditions of the lowly, raise the health level of the weak, and provide wider economic and cultural opportunities for racial and religious minorities indirectly serve to stimulate the development of scientific ability.

There are a number of additional conclusions suggested by the material in this report. In view of the anticipated increase in the college-age population in the 1960's and in view of the probably continued shortage of scientifically trained persons, a greater emphasis on quality in educational circles is likely to result. All who want to go to college are not likely to be admitted. Probably not all who go to college at the present time should go, in view of their abilities or possible contribution to society and the best utilization that could be made of limited college facilities. At least in some colleges, the increase in enrollment of high ability students will probably be accompanied by a decrease in the enrollment of low ability students since the expansion of facilities and staff are not likely to keep up with the swelling ranks of applicants. The difference of opinion, therefore, between those who view higher education as the birthright of every citizen and those who consider it necessary solely for the intellectually able will probably become more pronounced.

Another point worth special emphasis concerns the type of education our future scientists and engineers receive. Although we will continue to live in a rapidly shrinking world beset by a race for more technological power and hence must strive to reduce our deficit of scientists and engineers, we must see that the education provided for our future men of science is not too technical, specialized, and narrow. There is a temptation to find the answer to our scientific manpower shortage in more vocational training, more technical specialization, and earlier introduction of professional subject matter. It may seem inefficient to include broad, cultural subjects in the program of a science or pre-engineering major since they do not appear directly to enhance his technical skills. It may even seem a waste of time and energy to let a young person start his education with one vocational objective in mind only to have him later change his program of studies when he makes a different vocational choice.

But as Wolfle and others have pointed out, there are advantages to the professions and to society in providing a broad educational background for all future leaders. Breadth and flexibility have their place. Recently professional schools have indicated the value of nonprofessional education for their students. Future engineers and doctors, for instance, have been advised not to neglect the nonscientific part of their education. Perspective, a type of mental discipline somewhat different from that exercised in scientific subjects, and a fitting for life rather than mere training for a job are provided by the liberal arts portions of a student's program.

Particularly at a time like the present, when no one can foretell which knowledge of what particular kind of subject matter will be required of scientists and engineers 10 or 20 years hence, it is essential that their secondary and undergraduate education be as liberal as possible to provide maximum flexibility and perspective. As Wolfle puts it, "The freedom to change plans, and the freedom to move from one field to another, gives a flexibility to the country's educated workers which enables them to adapt to changing conditions and changing demands."[3]

In terms of an individual's development, a liberal arts base is important for his professional training. Premature specialization tends to narrow the outlook of the technically trained person. A recent survey of college graduates pointed to the fact that the generally educated graduates tended to be the most active citizens, the most varied in their leadership, and those who seemed to lead the most productive, rewarding lives.[4] Unfortunately, a haughty superiority is often displayed by some persons whose higher education has been entirely concentrated in technical subjects. As an example, the vice president of a large industrial concern recently called liberal education "a fossil." It was his opinion that training in the classical studies, regardless of whether they disciplined or enlarged one's thinking, had little bearing on today's problems. Defining the cultured man as "one who has sufficient knowledge to fit his environment," his remarks concluded:

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[3] Wolfle, *America's Resources of Specialized Talent*, p. 74.

[4] Havemann and West, *They Went to College*, p. 152.

> "The Greeks and Romans were concerned with philosophy. The cultured man of the medieval era was the man of religion. With the Renaissance, literature and the arts became ascendant. Today, neither philosophy, nor religion, nor even literature and art are dominant. Standing over all in this era are science and the conflict of political ideologies."[5]

Many eloquent voices have been raised to emphasize the value of a liberal education. George Boas has reminded us that while the historian, the linguist, and the philosopher are not essential to defense, they are "merely essential to civilization."[6] C. W. deKiewiet has shown how society is poorer for the lack of that wisdom that comes from the humanities.[7] A. Whitney Griswold has described the "practical" values of the liberal arts, the purpose of which, he says, "is to awaken and develop the intellectual and spiritual powers in the individual before he enters upon his chosen career, so that he may bring to that career the greatest possible assets of intelligence, resourcefulness, judgment, and character."[8] F. G. Friedmann has declared:

> "The humanities represent the area of human endeavor in which such values as freedom and human dignity are recognized and preserved.
>
> "As to the problem of survival of our Western world, recent history seems to teach that our failures were due to lack of understanding of the human factor rather than to our shortcomings in the technological field. . . . An increased emphasis on relevant training and research in the humanities and the social sciences seems therefore to be called for."[9]

The view that any effort not directed to the advancement of technology is futile needs correction. Education is more than training. Its primary purpose is to make a person think, not to learn facts or to acquire a specialized skill. If better scientists are to be produced, their schooling must help them gain wisdom as well as knowledge.

A broad rather than a narrow education has another practical advantage which is related to the new concept of scarcity mentioned earlier and which bears repeating now. At first mankind faced a scarcity of materials—food, clothing, shelter. Later, with the development of early modern capitalism, a shortage of currency and credit instruments was apparent. With this problem solved, a shortage of power appeared to plague us. With the rise of industrialization we discovered our dire lack of natural resources. Our forests were being plundered, our oil and coal reserves were being depleted until a conservation program was undertaken. Now, our other shortages having been temporarily met, we are faced with a more desperate type—a shortage of trained intellectual ability. But we know about our shortage of trained ability only in the areas where we can measure that shortage—in the scientific and engineering fields. We have no knowledge now of what we may need in abilities as a result of present and future discoveries. In the area of human relations, for instance, our need for competent persons may be even greater, our problem more complex. In this respect, the liberal arts may be more practical than we realize.

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[5] Murphy, "Science as Culture." *Chemical and Engineering News*, vol. XXXI, no. 37 (Sept. 14, 1953), p. 3,729.

[6] Boas, "The Humanities and Defense," *Journal of Higher Education*, vol. XXII, no. 2, (May, 1951), p. 234.

[7] American Association for the Advancement of Science, *Proceedings of the Second Conference on Scientific Manpower*, p. 19.

[8] Griswold, "Liberal Education is Practical Education," *The New York Times Magazine*, Nov. 29, 1953, p. 64.

[9] *The New York Times*, Feb. 22, 1955.

Before leaving this subject, a word must be said about the antiscientific sentiment frequently found among the nonscientific members of the academic community. Much of the suspicion, ill will, and distaste for the sciences which persons in the nonscientific professions reveal reflects their own shallowness as well as that of the narrow specialist in science. Science has its place in the training of the humanist, just as the humanities have in the training of the future scientist. One without the other is incomplete in a world as complex as ours. While there is room for concern about the overemphasis on technology in our civilization, there must be concern for its underemphasis as well. Mark Van Doren once remarked that education will not be a success until the poet and the mathematician can sit down and discuss each other's problems and perspectives intelligently.

Any consideration of our current shortage of scientists must also be set in the context of the great strides made recently by the Soviet Union in its scientific and technical progress. Experts have reported that over recent years in Russia there have been rapid increases in the numbers of engineering graduates, increased governmental support of scientific research, and intensified emphasis on technical subjects in the Soviet school system, and have warned that the USSR is rapidly catching up with the United States in this area. By emphasizing science early in school, giving science a privileged position in its society, channeling its talented youth into technical careers, and moving its scientific specialists out of administrative posts into research work, the Soviet Union is making a strong bid for scientific superiority. While the number of engineering graduates in the United States declined from 50,000 in 1950 to 22,000 in 1954, the number graduating in Russia rose from 28,000 in 1950 to 53,000 in 1954.

It is now estimated that after 1960 there will be more engineers in the Soviet Union than in the United States. This rapid increase, coupled with the Soviet's continued emphasis on scientific development, serves to make our internal shortage of scientifically trained specialists not only serious in its own right but dangerous to the survival of the free world as well.[10]

If the production of scientists is indeed a critical phrase of the cold war, we are losing the struggle for survival in our schools. We have a shortage of scientists and engineers primarily because we have not considered it worth while to provide the schools, teachers, and facilities which would produce the talented specialists our economy needs. A nation of 167 million persons cannot very well maintain its rapidly expanding technological progress when only 100 or so new high school physics teachers enter the profession each year.

The present plight, however, is not the fault of the schools themselves. It is not the fault of pragmatism, nor Dewey's disciples, nor state or federal offices of education. It is the fault of us all, of a society that pays lip service to learning and ignores the teacher and the scholar in its midst, that relegates to an overworked, overcrowded educational system the nurture, training, guidance, and discipline of its children for a minimum of 10 to 12 years of their lives, that ties the financing of this inadequate system of public education to a tax system that leaves much to be desired. As many educators have indicated, the situation is now so desperate it will take shock treatment for the patient to recover.

Countless warnings have been issued on the dangers to a nation posed by a shortage of trained minds. As Sir William Roberts has observed, "The proximate cause of the downfall of states seems always to have been a defective supply of strong and capable men at the head of affairs, and in positions of trust."[11] However, in overcoming our shortage of scientists, A. W. Haslett cautions us not to yield to a short-sighted policy of scientific recruitment to the detriment of a more permanent, carefully conceived program encouraging talent in general.[12] And Henry Armsby has emphasized the point that, in our democratic tradition, direct controls over the flow of intellectual abilities into different areas must be avoided.[13] Many authorities have also exposed the fallacy of assuming that legislative action will by itself solve the scientific manpower problem. Legislation for the encouragement of scientific ability will not salvage that ability if it is not accompanied by public concern and support.[14]

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[10] For additional comment on this subject see De Witt (Nicholas), *Soviet Professional Manpower, Its Education, Training and Supply* (Washington: National Science Foundation, 1955), and United States Congress, 84th Congress, 2nd Session, Joint Committee on Atomic Energy, *Engineering and Scientific Manpower in the United States, Western Europe and Soviet Russia* (Washington, 1956).

[11] See Thornton, *Science and Social Change*, p. 34.

[12] Haslett, *Science in Transition*, p. 227.

[13] Armsby, *Scientific and Professional Manpower*, p. 4.

[14] American Association for the Advancement of Science, *op. cit.*, p. 15.

However, hopeful signs may still be discerned in this desperate situation. The loss of talent is great, the shortage of specialized persons serious, but the nation is becoming alerted and efforts are being made to meet the crisis. Despite the many dilemmas of what G. E. Hutchinson has called "our plutonian world," despite the perilous course we must take along the brink of destruction, the very science which has given us the weapons with which to destroy each other and extinguish our civilization has given us the tools with which to carve out an even better, more meaningful, more productive world than the one we now enjoy. The discoveries of the past will lie in the shadow of those still to come. The unknown in science is still much more vast than the known. What will be accomplished in the next 50 years could well outrival the accomplishments of the last 500.

Alfred North Whitehead has reminded us, "We must expect that the future will disclose dangers. It is the business of the future to be dangerous; and it is among the merits of science that it equips the future for its duties."[15] In the words of George Counts, "We are entering a new age in our history and in the history of mankind. . . . We stand between the agrarian and mercantile civilization of our ancestors and a strange and as yet undefined industrial civilization in which our children will live."[16] In his profound appraisal of modern science, Vannevar Bush declares:

> "The applications of science have built man a well supplied house, and are teaching him to live healthily therein. They have enabled him to throw masses of people against one another with cruel weapons. They may yet allow him truly to encompass the great record and to grow in the wisdom of race experience. He may perish in conflict before he learns to wield that record for his true good. Yet, in the application of science to the needs and desires of man, this would seem to be a singularly unfortunate stage at which to terminate the process, or to lose hope as to the outcome."[17]

We are on the threshold of great developments. We are witnessing the birth of a wonderful new age. Whether or not we will be able to see that new day may well depend on how successful we are in the coming years in encouraging the scientific ability in our midst.

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[15] Whitehead, *Science and the Modern World*, p. 298.
[16] Counts, *Education and American Civilization*, p. 9.
[17] Bush, *Endless Horizons*, p. 38.

APPENDIX A

A tax revision proposal to encourage women into careers

Ample evidence has been presented that this nation faces a serious shortage of scientific persons and that there is a great waste of our intellectual resources, particularly at the educational gap between high school and college. It has been suggested that this shortage of scientists can be alleviated, at least in part, through more effective utilization of women in the scientific fields. From what has been written we can assume that there is and will be a sufficient demand for scientists so that employment opportunities will exist for scientifically trained women if the women are available. We can further assume that psychological and sociological factors, rather than lack of intellectual capabilities, constitute the major forces deterring women from becoming and remaining active scientists. This chapter will outline a proposed revision of the federal income tax laws that would enable women who were career-oriented scientists, nurses, teachers, or specialists in other fields to remain active or to return to their professions.

A specialized training with earning potential is an asset every woman should possess, particularly in view of the acute need for more women in scientific and technical employment. According to estimates of the Women's Bureau of the Department of Labor, in 1953 there were between 18½ and 19 million women working in the United States. In 1955, 20 million women were in the labor force. Women now comprise 30 per cent of the whole labor force, a marked increase from 1940 when they accounted for 25 per cent. In 1953, 27 per cent of all married women were working. Put another way, more than one-half (55 per cent) of all working women were married. Approximately 25 per cent, or almost five million women who were gainfully employed, had children under 18 years of age, and of these five million, two million had children under six years of age.[1]

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[1] United States Congress, House of Representatives: 83rd Congress, 1st Session, *Hearings Before the Committee on Ways and Means on Forty Topics Pertaining to the General Revision of the Internal Revenue Code*, Part 1, (Topics 1–19), p. 32, 64.

Surveys conducted during the war years among employed women consistently showed that over 90 per cent of these women worked because of economic necessity and less than 10 per cent because of interest in their jobs. Single women, in addition to supporting themselves, were frequently financially responsible for dependents.[2]

More recently, a study was conducted by the National Federation of Business and Professional Women's Clubs of over 16,000 of its members consisting of a relatively large proportion of single women, college graduates, and high wage earners.[3] Of the 56 per cent surveyed who are or had been married, 43 per cent of those married, 44 per cent of those divorced, and one-third of those widowed had dependents whom they were supporting. Even where there was another person in the family contributing to its support, 54 per cent of the married women in this group were major contributors to family expenses. The study therefore concluded that all young women, no matter what their marriage expectations may be, should train themselves for long-term earning because, as the authors observed, very often marriage is no guarantee that a woman can cease to support herself or others.

On the psychological side, although an essential role of women is to bear and rear children, the assumption that marriage alone can fully and permanently satisfy the complex emotional needs of every woman is being increasingly questioned. Ever since the industrial revolution, when the factory replaced the home as the producing unit of society, marriage has ceased serving women as a partnership for integrated living and working. Such integration had once yielded them a large measure of satisfaction throughout their lives in many spheres of activity. Now, however, the home serves as a partial outlet for a talented woman. Thus, not uncommonly, married women are discontented and dissatisfied with an exclusively domestic role even while their children are young. Moreover, modern trends toward smaller families, simplification of housework through labor-saving devices, and prolongation of the life span which has significantly lengthened the productive period of a woman's life after her children have matured, have contributed to the mid-twentieth century phenomenon of the middle-aged woman who feels she has nothing to do, is not needed any more, and has no purpose left for the latter third or more of her life. Confronted with relative unemployment after children are grown, many women are gnawed by loneliness, frustration, and a sense of uselessness.[4]

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[2] Miller, "Women in the Labor Force," *Annals of the American Academy of Political and Social Science*, vol. 251 (May, 1947), pp. 41–42.

[3] Kass and Feld, *The Economic Strength of Business and Professional Women.*

[4] See Farnham, "Battles Won and Lost," *Annals of the American Academy of Political and Social Science*, vol. 251 (May, 1947), pp. 113–119; Miller, *op. cit.*

A zig-zag pattern of life thus awaits the talented woman in the modern world—a pattern marked by a series of periods when a woman is pulled alternately in different directions—first the period of school and work, then the period of withdrawal from a career after marriage and birth of children when she is occupied primarily with in-home activities, and finally, but not insignificantly, the long period of productive years after her children have grown and left home when she is again relatively free to pursue a career outside of the home. Although the majority of women are content to let their vocations become avocations during the years when they are raising their families, they should be made aware of the fact that the intensive job of motherhood is transient and that a stage may well arrive when, because of financial reasons or a psychological drive to feel useful and needed after children have matured, they may wish to procure interesting employment outside of the home. They should be prepared for that time. Every woman should be encouraged to proceed on the premise that it is sensible, whether she plans on marriage or not, to be trained in a field where if the circumstances demanded it she could command a good salary and prestige in an interesting job. Presumably, she will be no less desirable as a wife because she possesses a financially sound specialty and it may stand her in good stead if the need arises. Advanced education and training for earning power become a kind of financial and psychological insurance which no woman should be without.[5]

The financial value of an assured earning power can be best measured this way. If a woman should become widowed, her husband would have to leave her $57,000 in life insurance to give her an income of $3,600 a year for 20 years, or $67,500 in life insurance to give her that income for 25 years. And in a higher bracket, he would have to leave her $95,000 of life insurance to give her an income of $6,000 a year for 20 years or $112,100 of life insurance to give her the same income for 25 years. Phrased in reverse, the ability of a wife to earn $70 a week for 20 years is worth $57,000 in life insurance, and to earn that amount for 25 years is worth $67,500 in life insurance. In the higher bracket, her ability to earn $115 a week for 20 years is worth $95,000 in life insurance and to earn the same amount for 25 years is worth $112,100 in life insurance. The psychological value of an assured earning power is immeasurable.[6]

One of the problems we must face then is how to eliminate the conditions which handicap marriageable women in entering or returning to specialized careers. One deterrent to combining a career with marriage is the mechanical and financial problem inherent in trying to run a home smoothly and economically from an office or laboratory. If a woman does not hire domestic help to attend to her children and perform routine household duties, if she tries to hold down a position during the day and to spend her evenings and weekends performing these household chores herself, the resulting physical fatigue, elimination of her leisure, and general disruption of the living pattern to which the family had been accustomed when she stayed at home can easily quench her once eager desire to pursue a career. A career will not be worth the sacrifice demanded of her and her family. On the other hand, the cost of hiring the domestic help needed to run a home so that the family pattern will be maintained is almost prohibitive. These costs rise with the standard of living to which the family has become accustomed. In the case of a woman scientist, presumably a college graduate married to a college graduate, the family requirements are high. When the cost of these domestic services are subtracted from a woman's salary, after taxes, the monetary attraction in her return to employment loses much of its force. She may even come out in the red. A working wife and mother thus becomes a luxury that few families can afford.

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[5] See White, *Educating Our Daughters*, pp. 113-118; Gruenberg, "Changing Conception of the Family," *Annals of the American Academy of Political and Social Science*, vol. 251 (May, 1947), pp. 128-136; Miller *op. cit.*

[6] These figures are obtained from Flitcraft, Inc., *Settlement Options*, p. 660, and assume an interest rate of 2½ per cent although most insurance policies written today only guarantee a 2 per cent return. With a 2 per cent return, the amount of required insurance would be somewhat higher. The comparative figures do not take into account varying income tax effects.

Following is an illustration of this dilemma, taken from testimony presented to the House of Representatives in 1954. If a married couple has one child and the husband earns $6,000 a year, and if his wife is offered a job at $3,000 a year and has to hire a maid at $30 a week to take care of the child, the family's income and social security taxes would increase from $835.20 to $1,552.80 (using the 1953 tax rates). The maid, taking into account social security taxes on her wages, would cost $1,583.40 a year (without including the cost of workmen's compensation insurance required in many states, and averaging $50 to $60 a year). Under these circumstances the family would be left with a net increase in income of only $716 a year due to the wife's working. This amount is little more than enough to cover the cost of the wife's transportation to and from work, lunches, and the additional clothing required.[7]

The cost of child care, therefore, consuming so much of a woman's potential salary, tends to discourage even a mother with children of school age from returning to a career. There is no way to lessen the actual expense of child care. No mother wants a "bargain" when it comes to someone to care for her young. The adverse impact of this expense, however, could be alleviated by allowing an employed mother to deduct for income tax purposes the amounts she pays for child care, thus enabling her to work.

Persons engaged in a business or profession have always been permitted to deduct the cost of salaries paid their employees in computing the net income on which they will be taxed. They can also deduct such relatively optional expenses as costs of entertainment of customers, office parties, attendance at meetings held in resort centers, dues at country clubs and social clubs (if they use these contacts for business purposes), so long as these are incurred "for the production or collection of income."[8] But until 1954, although business and professional men could deduct such items, a woman was not permitted to deduct the cost of a nursemaid whom she was compelled to hire to care for her children to enable her to work. Although, under law, all "ordinary and necessary expenses paid or incurred . . . for the production or collection of income" were deductible, the Board of Tax Appeals had held that the cost of a nursemaid enabling a mother to work was a "personal expense" and not deductible.[9]

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[7] United States Congress, House of Representatives; 83rd Congress, 1st Session, *Hearings Before the Committee on Ways and Means*, p. 67.

Section 214 of the new Internal Revenue Code of 1954 finally recognized the principle that child care expenses, incurred to enable a mother to work, are directly related to the production of her income and are income-tax deductible. The new law is a first step in the right direction, but it is a very short step because of its limitation on the amount of the deduction and the situations where it can be utilized. A deduction is now allowed up to a maximum of $600 a year for a single woman, widow, or widower to cover expenses paid for the care of dependents (not only children) when such expenses enable the taxpayer to be gainfully employed. Different rules apply to married women, however. If a woman is married and if her husband is incapable of self-support because of mental or physical defects, then a wife is permitted to get the $600 benefit. But, in the case of the average married woman whose husband is not incapable of self-support, this theoretical $600 deduction is reduced by the amount by which the adjusted gross income of both husband and wife exceeds $4,500. In other words, if a husband and wife together earn $4,500 or less in salaries, the wife can take the full $600 deduction. However, if their total salaries are $5,000, for example, the deduction is reduced by $500 (i.e., the amount by which their $5,000 in salaries exceeds the $4,500 maximum) and only $100 of the deduction is available to them. As soon as a couple has combined salaries of $5,100 or more, the new Code denies any deduction whatsoever for child-care expenses.

In the Hearings held before the Committee on Ways and Means of the House of Representatives at the time the committee was formulating the new tax law, it was made clear that the bill was designed to ease the plight of those needy families where wives, out of dire necessity, were forced to work. Unquestionably, families in such financial straits merit this tax relief. The present law helps them, but even then only to a limited extent because of its $600 maximum. However, the new Code will be of negligible value to the inactive married woman scientist or specialist, who is probably married to a college graduate earning a reasonable salary. Presumably the salary which she would receive upon returning to her profession, when added to her husband's, would exceed $5,100, thereby preventing them from taking any deduction for child-care expenses.

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[8] Section 23(a)(1) of the *Internal Revenue Code of 1939*, now 162 of the I.R.C. *of 1954*.

[9] *Henry and Lillie C. Smith v. Commissioner of Internal Revenue*, 40 Board of Tax Appeals. 1038 (1939)

The limitation imposed by Section 214 is unfortunate insofar as attracting women to science is concerned. A corporation can deduct the full cost of salaries paid its employees regardless of how much profit the corporation makes. The amount of its profits is irrelevant. There is no logical ground for a limitation, based on the combined income of husband and wife, of the amount a woman can deduct for the salary of an employee whom she hires to enable her to work.

Greater deductions for child-care expenses would go far in eliminating the major financial obstacle deterring married women from returning to their vocations. Witnesses at the Congressional hearings repeatedly emphasized the fact that tax relief of this nature was a tool within easy grasp of the government to attract more "womanpower" into various fields in which there is a critical shortage of manpower and that in the interests of our national defense program a bill allowing broad deductions should be enacted. One witness stated:

> "At times, a tremendous effort is made to induce women to enter the working force. Such occasions arise now in the case of special skills, such as nursing, and in areas of severe labor shortage. In general mobilization for war, a major part of the increase in the labor force would have to come from the ranks of women. But for many mothers the proposal that they go to work confronts them with very real financial questions in addition to the difficult decision as to whether they wish to leave their children during the period of work. Prospective earnings are slashed by costs of clothes, carfare, and meals away from home, as well as by child-care expenses. In many cases, these expenses, when not allowed through deductions from taxable income, mean that there is virtually no addition to net family income—certainly not if adequate provision for child care is made. Thus the overcoming of manpower shortages and rapid mobilization to meet a war-time emergency would be facilitated by the type of amendment (permitting the deduction of child-care expenses) we support."[10]

To the same effect was a Congressman's comment that:

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[10] United States Congress, House of Representatives; 83rd Congress, 1st Session, *Hearings Before the Committee on Ways and Means*, p. 70.

". . . the present inequitable tax law (denying any deduction for child-care expenses) has an adverse effect on the welfare of the country by making it difficult to keep women in the fields of teaching and nursing where a critical labor shortage exists. Teachers and nurses are traditionally underpaid, and by the time nondeductible child-care expenses are subtracted, it is hardly worth while for these women to continue to work, once they have families."[11]

Representative Roberts read to the committee a letter from a dean of education of a large eastern college who favored such a law as a step to alleviate the teacher shortage and stated:

"This bill (permitting broader deduction for child-care expenses than were finally enacted) is indeed a step in the right direction and will go a long way toward alleviating much of the teacher shortage in the United States. In the past seven or eight years, I have talked to many school superintendents who have canvassed their communities in an effort to find qualified teachers for their schools. Many found them all right, but couldn't talk them into taking the job because these women could not deduct the expense of household help which they would have to get in order to hold a public school job. In many instances they would actually have been losing money."[12]

A representative from the American Nurses Association stressed the value of child-care deductions in bringing inactive nurses back to their profession. She said:

"We have discussed so far the effect of the proposed amendment upon active nurses and the inequities which the amendment would remedy, but perhaps even more important from the viewpoint of the national economy and public interest is the effect which such an amendment would have in bringing inactive nurses back into the profession. Of the 222,000 inactive nurses, approximately 58 per cent have children under 18 years. In other words, although 60 per cent of all registered nurses are now active in nursing, only about a third of those with dependent children are practicing their profession. . . .

"The situation of one ANA member in one of the larger midwestern cities may be taken as typical. She has one child. Her salary as a general duty nurse would be $225 per month. The child is too young for school, so that full-time help is required at home. A housekeeper or nursemaid to care for the child while she works would cost her at least $135 a month (including lunches) . . . (carfare, uniforms, laundry, etc., cost $50). Her working expenses thus total $185 of her $225 salary, leaving her only $40 before deductions for taxes and social security. This nurse's decision to accept a job in the hospital where she is urgently needed or to remain at home will be greatly influenced by whether or not she is allowed income tax deductions for child-care expenses. . . .

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[11] *Ibid.*, p. 39.

[12] *Ibid.*, p. 40.

"While I have emphasized in my testimony the effect that the amendment would have upon active and inactive nurses, it is obvious that the bill would also encourage skilled women in all occupations to return to the labor force."[13]

A representative of the American Hospital Association advocated the passage of a bill for broad child-care deductions on the following grounds:

"Because hospitals are maintained on a 24-hour basis seven days a week they offer opportunity and considerable appeal to working wives and mothers who want part-time employment or unusual working hours. . . .

"We suspect that there may be a considerable reservoir of such marginal workers who would be willing to accept hospital employment if their added expenses for care of children . . . would not make such employment financially unprofitable. With the shortage of good employees in the hospital field, we believe that permitting such individuals to take this deduction might add to the available working force for hospitals."[14]

The above quotations corroborate the belief that broad deductions for child-care expenses would reduce the major financial deterrent keeping mature women, including inactive women scientists, from returning to their professions. Such an amendment of the law would provide not only more tax relief for the needy and widowed, but would offer to women who can command larger salaries because of their special skills a tax incentive to return to work. And it is these women with specialities, whose abilities are needed by the country, who are remaining at home, deterred from utilizing their skills because of an anachronistic tax law.

Ideally, the law should permit full deduction from gross income of the actual amount paid for care of dependents enabling a woman to work, with no limitations. Since the enactment of such a sweeping bill is unlikely, however, the following compromise provision is recommended: Any woman (single, widowed, or married) should be permitted to deduct from her gross income the amount paid for the care of any children or stepchildren under the age of 17 years or for the care of any dependents incapable of caring for themselves (when payments for such care enable the taxpayer to be gainfully employed). The deduction would be subject to the following limitations. It could not exceed a maximum of $1,800 per year or one-half of the gross income earned by the woman—whichever is less. Moreover, the deduction would not be permitted for amounts paid to a relative for whom the taxpayer claims an exemption as a dependent and would not be permitted with respect to amounts paid an individual as wages unless social security taxes were paid by the woman on such wages.[15]

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[13] *Ibid.*, pp. 50–52.

[14] *Ibid.*, pp. 60–61.

The above provisions would have the following advantages over the present law. First, the maximum deduction would be raised to $1,800, a figure which approximates more realistically the cost of a full-time nursemaid than the present $600 figure. Moreover, in contrast to the present law which penalizes husbands and wives with a combined earning power over $4,500, the proposed deduction would be fully available regardless of the high income of the wife or of the husband. Since one of the objectives of such tax relief is to attract back to their professions skilled trained women, probably college graduates with husbands earning reasonable salaries, the objective would be defeated if this $1,800 maximum were reduced because of the fact that a woman was sufficiently trained and skilled to command a good salary herself or because her husband had a substantial income. Therefore, high earnings of the woman or of the family would be irrelevant and would not prevent taking the full deduction. However, on the other end of the scale, in order to prevent abuse of the law by women not seriously employed but trying to claim a deduction for child-care expenses beyond the amount of child care related to employment hours, it is proposed that the deduction be $1,800 or no more than one-half of the income actually earned for employment by the woman herself whichever is less.

A second advantage is that deductions could be made for the care of children through the age of 16 years instead of through the age of 11 as the present law provides. In view of the recent statistics on juvenile delinquency, competent household supervision of young teen-agers should be encouraged.

Third, under this proposal, the deduction would be subtracted from gross income in calculating adjusted gross income and would not be part of the itemized deductions from adjusted gross income. For those families who do not have sufficient other expenses to justify itemization of deductions and who would normally use the optional 10 per cent deduction, the present law requiring that child-care expenses be claimed only from adjusted gross income (i.e., only if deductions are itemized) may nullify the deduction. Employees in some circumstances can exclude from their gross income a portion of their wages received under wage continuation plans for sickness or injury. Stockholders can exclude a fixed portion of their dividends from gross income.

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[15] This recommendation combines elements from various bills proposed to the House of Representatives.

Persons engaged in a job or profession can deduct employees' salaries from their gross income. There is precedent and justification for permitting working mothers to do the same rather than restricting this deduction to adjusted gross income.

An illustration of the hardship worked by the present restriction is the following. In a situation where a husband earns $3,000 and a wife $2,000, with $900 paid to a nursemaid, the present law would permit the couple to deduct for child-care expense only $100 (i.e., the $600 maximum reduced by the amount by which their combined earnings exceed $4,500). This $100, however, will actually be claimed by the family only if a husband and wife have spent at least $500 in addition for charity, taxes, interest, allowable medical expenses and the like, therefore making it worthwhile for them to itemize deductions rather than to take the flat 10 per cent optional deduction which would give them a $500 blanket deduction. If they have spent less than $500, they will lose money by itemizing in order to get the so-called child-care tax relief.

On the other hand, the tax relief proposed herein would benefit this family as follows. The $900 paid the nursemaid (since it is less than the $1,800 maximum suggested and is also less than one-half of the woman's earnings) could be subtracted in full from the gross income of $5,000, leaving $4,100 of adjusted gross income. Then the 10 per cent standard deduction would be applied against the $4,100, leaving $3,690 of taxable income compared with $4,500 in the first illustration.

A fourth advantage of the recommended tax revision is that it contains a safeguard against potential abuse of the law not presently found in Section 214. The limitation of the deduction for wages paid for child-care services (as distinguished from payments to a nursery school) to situations where social security taxes are paid on the individual's wages serves as a safeguard preventing the attempted use of the deduction for casual baby sitters.

Finally, although the allowance of broad child-care deductions would decrease the government's revenue, it involves certain factors which would in part offset the loss. A woman would always have to earn at least twice as much as she could deduct for child-care expenses. Therefore, if the legislation encouraged inactive women to return to positions now unfilled, it could increase the revenue of the government since the woman's earnings would constitute a new source of taxable income. Moreover, the wages paid by the woman for child care would be subject to income tax in the hands of the recipients, although at lower rates. Tax relief of this nature, whether in the form proposed or with modifications, merits serious consideration in any overall governmental plan to try to attract mature women with special skills and training, such as women scientists, back into fields in which a critical manpower shortage exists. Such tax revision could serve to unfreeze the wealth of skills possessed by countless mature married women for utilization by society in all areas of thought and endeavor.

Allaire U. Karzon

APPENDIX B

Political science, the sciences, and the public service

Political science and the natural sciences

Is political science really a science? If so, in what sense can it be called a science? These questions are inevitably raised in any discussion of the status of political science as an academic discipline or of its relationship to such sciences as physics and chemistry. For many students of government and politics the usual positive and negative answers to the question, "Is political science a science?" have become so stereotyped and familiar that they are strongly tempted to slip away from any group that embarks on a discussion of this subject. Although a definitive answer to the question may not be attainable, it may be useful to make a brief effort to clarify the meaning of the term "science" and to discover in what, if any, sense of the word the study of politics is or can be made scientific.

First, we should note that the usage according to which "science" refers only to the natural sciences is a comparatively recent development in Western thought. For thousands of years "science" and its Latin original, *scientia,* which was itself a translation of the Greek *epistēmē,* carried the much more general meaning of an organized and systematic body of knowledge. Theology, which would hardly be acknowledged as a science by many of our contemporaries, was once considered to be the queen of the sciences, while philosophy was regarded as the mother of the sciences. In German the term *Wissenschaft* still bears a large measure of this earlier and wider meaning of "science." Even today the proper translation for our English word "science" is usually *Naturwissenschaft* rather than *Wissenschaft;* the latter includes two main divisions, *Naturwissenschaft* and *Geisteswissenschaft.* In view of the sharply delimited sense in which most people now use the English word "science," the latter term, which for many purposes is extremely useful, is virtually untranslatable; both "Cultural Science" and "Science of the Mind" are rather unsatisfactory renderings.

In its most general sense science may, perhaps, be defined as the search for order and connection among natural events or human actions. This search begins—like all searches—in doubt and questioning. Formulating the question or problem which we are trying to answer is itself a significant part of the process of inquiry. Along with the formulation of the question we begin to frame vague and tentative answers, based on our previous experience in similar situations, on our general knowledge of the particular subject matter with which we are dealing, and on the operations of the little understood faculty of creative imagination. As we proceed, we sharpen and refine both the question and the answer. At the same time we check the hypothesis or tentative answer against the elements in the situation that are regarded as given or known—what we call the evidence or the facts. Sometimes we can test the hypothesis directly; for example, we wonder whether an empty gas tank is the reason why our car has stopped, and we check to see whether or not there is any gasoline in the tank. Sometimes we can only test our hypothesis indirectly by deducing from it a series of consequences and then seeing whether the "facts" correspond to some of these consequences.

The results of our direct and indirect testing of the answer by reference to the evidence may—and often do—force us to abandon the hypothesis or to reformulate it. But even if we do not meet with such rebuffs in our efforts to frame a satisfactory answer and even if the facts seem to confirm our hypothesis, we can never say that the answer has been proved to be absolutely true in the manner of a mathematical demonstration. All we can say is that our answer is more valid than any alternative explanation that now occurs to us. It provides a more satisfactory answer to our original question than any other formulation, and it is consistent with the other hypotheses or theories which, provisionally at least, are regarded as established in the field in which we are working. But changes in these other theories, new evidence on our particular problem, or a more insightful and imaginative re-examination of the present evidence (or some combination of these) may compel us to surrender or to modify our hypothesis.

In my view, nothing that has been said so far about the general procedures which constitute scientific inquiry forces us to limit the meaning of "science" to the natural sciences and to exclude the disciplines that study man and his works. I believe that the brief outline of scientific method that I have given is just as applicable to the work of the scholarly historian as to the investigations of the physicist or chemist. Therefore I see no reason for making a rigid separation between the natural sciences and the studies of human actions, or for denying the possibility of social science or of political science as one of its divisions.

Are there then no significant differences between the natural and the social sciences? Of course there are. And in my view much of the present confusion and sterility in the study of human problems is the result of insufficient attention to these differences. Many psychologists, sociologists, and political scientists mechanically imitate the quantitative and experimental methods of inquiry of their colleagues in older and more successful disciplines—physics and chemistry—and therefore fail to come to grips with their own problems and to arrive at answers appropriate to them. The model of the highly developed science of modern physics has been extremely seductive to many social scientists. Insofar as it has led them to attempt to develop a general theory of society into which all particular problems and investigations can be neatly fitted, it has probably done more harm to the development of our knowledge of man than any other factor. The social sciences have not yet gone through their Newtonian phase—if indeed they will ever do so—and yet some of our contemporary social scientists seem to be trying to move directly into the post-Einsteinian period.

Many of the differences between the materials of the natural scientist and those of the social scientist are obvious to any observer. The data with which the student of man and society is dealing are much more complex and unstable than the facts of the natural world; the process of inquiry and investigation itself leads to a general awareness of the phenomena under study, and this awareness often leads to changes in the attitudes and behavior that are being investigated; the investigators' own beliefs, prejudices, and values are much more directly related to the facts they are studying than are the personal views of the natural scientist; and since human beings are the subject of study, the range within which controlled experimentation can be carried on is—at least in civilized countries—relatively narrow.

Perhaps the most important difference between social science and natural science is the fact that the student of society or politics is often dealing with structures or entities that are virtually unique and that are the result of a long process of historical development. The American Constitution, the British Cabinet system, the French political party structure, the Japanese religious-political system—each of these is a unique entity, developed over a long period of time and unintelligible apart from its historical development and from the internal and external factors that have contributed to it. As a result, generalizations about constitutional development, party structure, etc., which attempt to rise above these concrete entities, are much more difficult to formulate than generalizations about atoms and molecules, which behave in the same way under the same conditions, no matter where they are found or when they are observed.

More significantly, however, the generalizations of the social and political scientist often fail to include the most important elements in the phenomena being compared because they are the elements peculiar to the Japanese, English, or French situation. The stress on purely "contemporary," "cross-sectional," "functional" analysis of political and social processes, coupled with disregard for the historical matrix out of which the present situation has emerged, lead the "scientists" to generalizations that are often superficial and mechanical (compare most of the discussions of "feudalism" in Japan) or pretentious and thin. While they are based on observation of a single moment in a long and complex historical process, they are often presented as eternal verities. In this connection one needs to remember only the confident descriptions and prescriptions about postwar Germany and Japan made by many social scientists who were often happily unaware of anything that had happened in either country before 1939. The inadequacy and pretentiousness of the "answers" are not, however, the worst result of this aping of the techniques and procedures of the natural scientist. The real tragedy is that the questions and problems that are the real business of the social and political scientist—understanding this or that institution or structure or process in all the complexity and uniqueness of its historical context—are largely ignored. So we cannot go on to ask how well or badly the institution is now doing its job and how it might be modified in order to improve its performance.

I do not mean to suggest that the student of society or politics should reject the scientific method in the sense in which I have tried to outline that method in this paper. Indeed, I see no alternative to that method of systematic question and answer, controlled by reference to the evidence, and consciously empirical in attitude and approach. I ask only that social and political scientists be truly scientists rather than devotees of "scientism," that they deal with their own problems rather than pseudo-problems which happen to be amenable to investigation by techniques developed by other disciplines, and that they formulate their hypotheses in terms of all the significant facts and not solely in terms of the artifacts that emerge from questionnaires and IBM machines. "Common sense" reflections about social and political questions, to say nothing of the classic works in these fields, have achieved a significant amount of understanding of the processes and institutions of politics and society, and, up to a point, they are adequate as guides to action. Their success, limited though it has been, has not been achieved by a slavish imitation of the techniques and procedures appropriate to other problems or other sciences. Dissatisfaction with existing methods and conclusions in the study of politics should not lead us either to embrace "scientism" or to abandon the scientific approach in favor of "intuition" or *a priori* dogmatizing. We must continue to formulate hypotheses to answer the questions that arise in our political activities and to test their validity by reference to empirical data, using methods that are public and communicable in character. But we must not close our eyes and our minds, in advance, to 90 per cent of the evidence that is available and pertinent to our problems on the ground that the data do not fit some arbitrary notion of what constitutes evidence—e.g., that the data must be quantitative, contemporary, "behavioral," or material for "generalizations" or "laws" of political behavior.

It is clear, then, that political science is not now a science in the sense that physics is; it does not possess a well-established body of general theoretical propositions, mutually interconnected and consistent, from which, given certain statements of boundary or initial conditions, particular conclusions can be deduced that can then serve as predictions of events that will occur in the future. I have given the reasons that persuade me that, in view of the material with which the student of politics is dealing, political science cannot be a science of this kind. But even at the present time there exist in each of the major areas of political science—public law, the study of the political process, comparative government, international relations, and public administration—systematically organized bodies of data and explanations, which, though inadequate and partial, are both useful in understanding the political problems that confront us and communicable to students and to others who are interested. Moreover, the tradition of Western political thought offers a body of elaborately worked out discussions and analyses of political behavior in a wide variety of contexts and of the political and ethical values that are inextricably interwoven with that behavior.

There is another fundamental difference between the natural sciences and political sciences. Because of the importance of the connections that exist between politics and many other aspects of human activity, most of the best teachers of political science in the United States today would not, I think, recommend that students, particularly if they plan to go on to graduate work in the field, spend a large part of their time and energy as undergraduates taking courses in political science (American government and politics, public administration, comparative government, international relations, etc.). There is a widespread feeling that the undergraduate in a liberal arts college should build his program around the central disciplines of history, philosophy, literature, mathematics, and languages, with some attention to the more specialized fields such as economics, sociology, anthropology, and political science. With this background he is far better equipped to begin intensive graduate study in political science than if he has concentrated on courses in government.

In part, this situation reflects the close connection that exists between the study of politics and the other disciplines that deal with human actions, especially history. In part, too, it is a reflection of the fact that political science has no specialized vocabulary of its own. An undergraduate who is planning to do advanced work in mathematics or physics must spend a large part of his time in acquiring the mathematical and scientific vocabulary without which he will be literally incapable of understanding his teachers or his texts at the more advanced level. Although there have recently been some efforts to introduce a precise technical vocabulary into the field of political science, they have failed because they have in the main been ignored. Almost all of the phenomena with which the political scientist deals are already named in ordinary speech, and it would be incredibly pedantic to coin neologisms for Congress, its committees, statutes, the courts, their opinions, political parties, etc. Occasionally, when one is attempting to explain some event or institution, one finds it convenient and perhaps necessary to manufacture a technical term in order to have a simple label or symbol for a complex process. Technical terms of this sort are, however, rare. If the absence of a technical vocabulary is sometimes a handicap to clear and precise thinking in political science, since ordinary words carry with them much of the vagueness and emotional aura that they bear in common speech, it is also a great advantage. The writings of political scientists are, at least in principle, accessible and intelligible to the educated layman without any process of translation or popularization. Students of politics do not, therefore, have to deal with a disparity similar to that existing between the language of the physicist and the vocabulary of the ordinary citizen.

Another reason for the difference in training between the political and the natural scientist and for the emphasis on general rather than specialized training for political scientists during the undergraduate years is that, at least up to the present time, political science has not developed a method of study that is peculiarly its own. In its formal as well as its societal aspect, political science has a relatively well-defined content, the political and governmental process, the ties and connections between the governmental and legal structure, and the activities and ideas of various groups of people (social, economic, and religious groups, as well as political parties and associations). But in analyzing political problems and processes the political scientist uses a wide range of methods, among them the methods of the historian, the economist, the sociologist, the psychologist, the philosopher, and the lawyer. Even in the recent efforts at a more "scientific" study of political behavior there is no indication that methods of research and investigation peculiar to political science are being developed or even contemplated; in fact, the newer approach is marked by an effort to apply to the study of political problems certain techniques that have already been used in other social or natural sciences.

If we look at some of the recent surveys of the research that is being carried on by political scientists throughout the world and, in particular, in the United States, certain trends seem to be fairly well defined. Since the publication of Professor Carl J. Friedrich's article on "Political Science in the United States in Wartime"[1] in 1947, there has been a steady stream of surveys and analyses of current work in the field.[2] In 1950 UNESCO published a volume entitled *Contemporary Political Science* which contained a survey of the study of politics in a large number of countries, including 10 papers on American political science. The most striking development in America in 1948–49 seemed to be a steady shift of attention from the older study of formal institutions and structure to a concern with the processes of politics; much of this concern was focused on the study of political parties, public opinion, and "pressure groups." The works of V. O. Key[3] and David B. Truman[4] represent perhaps the most distinguished products of this new approach. In terms of method, the "new" political science stresses the analysis of contemporary political processes and is less interested in historical treatment; it has a high regard for quantitative techniques and seeks to apply them wherever possible; it aims to build up from its careful observations of contemporary facts a behavioral political science that will possess wide applicability and predictive power.

In all these respects, devotees of this approach to the study of politics often seem to me to be verging perilously close to the kind of "scientism" discussed above, especially when they allow their zeal for external and mechanical gadgets resembling those of the natural scientist to lead them away from the heart of the scientific method. Another feature of the "new" political science has been the emphasis on large-scale, cooperative research projects; in order to conduct such studies, new research organizations, particularly in the field of public opinion polling and analysis, have been created within or outside the traditional university organizational pattern.

Two other features of postwar American political science seem to have struck most observers as noteworthy: first, the great expansion of research and teaching in the area of international relations,[5] and second, the aspiration on the part of a number of political scientists working in both international and domestic politics to contribute to the process of policy formation by governmental agencies.[6]

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[1] *American Political Science Review*, vol. XLI, Oct., 1947.

[2] See the recent publication, *The Social Sciences in Historical Study*, Social Science Research Council Bulletin 64, 1954, esp. pp. 68–72.

[3] Key, *Politics, Parties, and Pressure Groups;* Key and Heard, *Southern Politics in State and Nation.*

[4] Truman, *The Governmental Process.*

[5] During the period 1946–48 in 252 reporting institutions, 19 new courses were added in the field of international relations, 22 in international organization, 11 on the United Nations, 16 on international law, 34 on Far Eastern government and politics, 29 on the Soviet Union, and 26 on Latin America. There were 129 other new courses in all other areas of political science. See Report of the Committee for the Advancement of Teaching, American Political Science Association, *Goals for Political Science*, p. 105.

In 1952 an article by C. E. Hawley and L. A. Dexter, "Recent Political Science Research in American Universities," the report of a study conducted by the Committee on Research of the American Political Science Association and the United States Office of Education, appeared in the *American Political Science Review*.[7] In June, 1954, the *Review* published an article entitled "World Trends in Political Science Research" by C. B. Macpherson which summarized both the UNESCO and the Hawley-Dexter surveys and commented on developments in the years since 1948-49.[8] Professor Macpherson notes that in the United States the emphasis continues to be on empirical research, directed towards the "process of government" rather than the formal structure:

> "The dominant trend, in the political scientists' conception of their task, and in the sort of questions they set themselves, is clear enough. There is an increasing amount of more strictly empirical research, of which much, though not all, is being done with a sense of the need for a systematic general theory. Underlying this development is an uneasiness about the adequacy of existing political knowledge and existing political science methods."[9]

He also observes that the major interest has been in the electoral and representative process (the formulation of public opinion, political parties, "pressure groups," etc.), rather than in the purposes of the political process and the extent to which current institutions and processes satisfy the needs of the ruled. He cites the Cornell Studies in Civil Liberties, supported by the Rockefeller Foundation, as one of the few items of extensive research into the exercise of political power and its impact upon the citizen.

Illustrative of the "new" political science, although far more sophisticated and elaborate than most of the proposals for empirical research on the political process, is the comprehensive research plan developed by the Social Science Research Council's Committee on Political Behavior and reported in the *American Political Science Review* for December, 1952.[10] The Committee shows great interest in precise definition of terms and hypotheses and in careful effort to test the validity of hypotheses. It should be noted, however, that efforts of this kind at careful formulation of "scientifically" testable propositions sometimes seem to end in the construction of near-tautologies or truisms.

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[6] Note, for example, Harold Lasswell's emphasis on "policy science."

[7] Vol. XLVI, June, 1952, pp. 470-485.

[8] Vol. XLVIII, June, 1954, pp. 427-449.

[9] *Ibid.*, p. 447.

[10] Eldersveld, S. J., *et al.*, "Research in Political Behavior," *American Political Science Review*, vol. XLVI, Dec., 1952, pp. 1,003-1,045.

Political science and the public service

With the vast expansion of governmental activities into new areas of social concern during the past quarter-century, there has been a great increase in the number of persons with college and university training who are employed by the federal, state, and local governments. Dean Paul Appleby of Syracuse University has estimated that about 15 per cent of all holders of the bachelor's degree in the United States are now in government service.[11] Although lawyers constitute now, as in the past, a large proportion of the "administrative" group in the public service, they have recently been joined by a large group of men and women trained as economists or political scientists. In recent decades many people have felt that the lawyer's capacities and talents, while they might have been sufficient background for a career in "administration" during the period of the "negative" or laissez-faire state, need to be supplemented with the skills and attitudes of the political and social scientist now that government on all levels is intimately involved with political, social, and economic problems. The following figures may serve as one example of the movement of highly trained political scientists into government service. In the period from the academic year 1934–35 to the year 1937–38, Harvard, Columbia, Princeton, Iowa, Chicago, and California granted the Ph.D. degree in political science and international relations to 115 persons. In a recent survey of their occupational fields it was found that, among the 103 responding, 17.5 per cent were in government service, about 70 per cent in education, and less than 6 per cent in business.[12]

This movement of political and other social scientists into government service was further accelerated by wartime problems of regulating the economy, shifting industry over to war production (and the reverse process of reconversion after 1945), large-scale shifts in population, geographically as well as occupationally, the creation of many new and complex administrative agencies, etc. In part, at least, the concentration of research and teaching attention among American political scientists during the 1930's and early 1940's on public administration and the domestic political process was probably a response to the need to supply new recruits for the ever-expanding bureaucracy at all levels of government. In part, too, this concentration of interest and concern probably reflected a widespread conviction that the new activities and interests of government were providing new problems for the attention of the student of political science.

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[11] See American Political Science Association, *Goals for Political Science*, p. 76.

[12] *Ibid.*, p. 256. It may be of some interest to note that these six institutions, during the period 1935–1948, awarded 420 Ph.D. degrees in political science and international relations, or 44 per cent of the total of 953 doctorates awarded by all American universities granting doctorates in these fields (numbering 50 in all) in this period. The addition of four more universities—Wisconsin, Yale, Stanford, and Pennsylvania—to the top six brings the total of Ph.D. degrees in these fields granted by the top 10 universities to 550 or nearly 58 per cent of the total (*Ibid.*, p. 248).

During the Second World War and until about 1951 in the postwar period, the government also brought great pressure to bear on American universities to expand their programs of training and research in international relations, especially in area studies.[13] The United States had to undertake new and important commitments, first in military government, and later as the leader in world efforts at postwar reconstruction. These attempts to rebuild shattered societies and economies required that a large number of Americans be trained to understand the institutions and problems of many countries of Europe and Asia. The postwar program of economic and political reconstruction gradually merged into even larger and more complex projects—such as the Marshall Plan, aid to Greece and Turkey, and NATO—designed to strengthen non-Communist nations against the threat of Soviet military and political expansion. All these programs involved constant demands for "administrative personnel" trained as experts in particular areas or in the general field of international relations. Both in their teaching and research programs, American universities responded with a great development of the fields of international politics and area studies, subsidized in part by government funds and by grants from private foundations. It should be noted that these developments have been criticized by some university administrators on the ground that they deflected financial resources and scholarly energies from other fields of learning to international studies; when, as often happened, governmental agencies and foundations abruptly shifted their interest and support to other projects, the university was left saddled with long-term commitments and responsibilities. This problem is obviously related to the general concern felt by many natural scientists about the stress laid on applied research and scholarship, at the expense of "pure" or basic research, as a result of governmental pressures on universities.

At the national level this trend toward expanding the public service has been partially reversed during the last few years. The Eisenhower Administration has reduced the number of administrative personnel in agencies and bureaus dealing with domestic problems, and it has not continued the expansion of personnel in agencies dealing with international issues (the Foreign Service, Mutual Security Agency, etc.). As a result, university graduates trained to undertake work as civil servants in government agencies have found that their services are not in demand, and that there is actually an exodus of trained and experienced career administrators from Washington. At the moment, then, it seems likely that, relative to the demand, there is an oversupply of persons trained in public administration, politics, and international relations. However, this is probably only a short-term situation. If we presume that the government will continue to be concerned with the operations of the economy and society and that complex and difficult international problems will persist for a long time, it is likely that the general twentieth century trend towards the expansion of government personnel to deal with these problems will be resumed.

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[13] Compare, for example, the various military government programs and the numerous Army Specialized Training Program activities established at universities during the war.

Whether or not we ever discover that we face a shortage of political scientists or other social scientists as critical as our current need for more physical scientists, engineers, and technicians, it would be well to recall Elbridge Sibley's conclusion in his 1948 study for the Social Science Research Council:

> "There is indeed need for more liberal financial support of the social sciences, but it is not safe to assume that the simple expedient of investing larger sums in subsidies to students of social science would automatically yield proportionate returns in the advancement of social science. Nor does it appear that the most immediately urgent problem of the social sciences is the recruitment of more students of superior ability. The first task is to improve the training offered."[14]

Another facet of the relationship between government service and political science in the United States that merits some attention is the fact that, in recruiting administrative employees for all levels of government, we have tended to hire people who have been highly trained as specialists in economics, law, public administration, statistics, accounting, personnel administration, and other rather narrow fields. This pattern has had the effect of imposing rather strong demands for specialization and quasi-vocational training upon our colleges and universities. In England, on the other hand, members of the administrative class of the civil service, recruited largely from the best students at Oxford and Cambridge, have not entered government service as specialists. Educated in a broadly humanistic fashion, they have been assumed to have the intelligence and elasticity to acquire a variety of special skills and knowledge as they move from one agency or department to another.

Our pattern of specialization, which has produced college graduates trained in forestry or municipal administration, or more recently in "Far Eastern problems," may have been necessary in view of the rapid and sudden expansion of governmental activities and personnel. Questions arise, however, about the adequacy of the supply of administrators who have a broader background than that of the specialist and are therefore able to move flexibly to deal with new problems. Not the least of these problems is the need, at every level of the work of a government department or agency, to coordinate the activities of a number of specialists, each of whom is unlikely to be aware of the others' skills and problems. Two years ago, when I had occasion to discuss with a number of people in business and government as well as in universities the problems of developing and strengthening the fields of political and legal philosophy, I often found that I encountered more sympathy and understanding of the issues that concerned me from senior officials in government and business than from many academic people. Repeatedly, those who occupied positions at the upper levels of private and public "bureaucracies" complained that, although they could find relatively well-trained specialists among recent college and university graduates, they were finding it increasingly difficult to recruit, at all levels, people who had the ability to synthesize and coordinate the findings of the specialists in order to apply them to the actual problems at hand, which often resisted neat reduction to the categories of specialization.

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[14] Sibley, *The Recruitment, Selection, and Training of Social Scientists*, p. ix.

Some years ago, in writing about the relation of university education to the public service, the late James Forrestal remarked:

> "I believe the broad general training is preferable. . . . I have observed what seems to me to be some imbalance in the predominance of statisticians, lawyers, and economists in our government as contrasted to the number of men drawn from a more general experience. Training in the categories I have named is useful, but I suggest that sometimes people with such specialized training tend to rely too much on the techniques of their training to the detriment of practical solutions. . . . To those who propose to enter the service of government, the university training should have as its objectives the capacity for clear thinking, for lucidity and clarity of expression and, above all, for the application of understanding and pragmatic methods, rather than dogmatic methods, to the human problems which are and always will be the main problems of government."[15]

A similar comment came from President Truman, speaking at the Princeton Bicentennial Conference on University Education and the Public Service in 1947. Mr. Truman noted:

> "The government has recruited from our academic institutions many members of its professional staffs—geologists, physicists, economists, and others with specialized training. . . . But we have been much less effective in obtaining

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[15] James Forrestal, "Managing the Public's Business," in *The Public Service and University Education*, ed. by Joseph E. McLean, pp. 241–242, as cited in American Political Science Association, *Goals for Political Science*, p. 78.

persons with broad understanding and an aptitude for management. We need men who can turn a group of specialists into a working team and who can combine imagination and practicability with a sound public program. . . . Men trained for this kind of administrative and political leadership are rare indeed. . . . [The universities] should develop in their students the capacity for seeing and meeting social problems as a whole and for relating special knowledge to broad issues."[16]

Many of the government and business leaders with whom I have discussed this problem have been at least interested in the possibility that the need for people who combine breadth of understanding with a practical attitude toward complex issues might be met, at least in part, by university training in the skills of analysis, synthesis, and the proper formulation (if not the solution) of problems that serious and sustained work in philosophical, historical, and literary analysis can provide. This issue, while it goes far beyond the scope of these remarks about American political science, has relevance to any discussion of the whole question of promoting and encouraging the training of a larger number of scientists in this country. To this larger discussion I should like to contribute only this general note of caution. We should recognize the possibility that general administrative and organizing talent of a nonspecialized nature may be a skill of which the supply is at least as short as that in particular specialties such as physics, chemistry, and engineering. The extraordinary growth and complexity of the large public and private agencies that increasingly dominate our lives, together with the growing proliferation of increasingly specialized skills which must be coordinated in any large-scale practical or research enterprise, mean that any failure in the supply of this generalizing and synthesizing talent may bring the entire structure crashing down around our heads even more rapidly than a shortage in the supply of one or more of the groups of specialists.

HERBERT A. DEANE

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[16] *The New York Times*, June 18, 1947, p. 20, as cited in *Goals for Political Science*, p. 80.

APPENDIX C

The national study questionnaire

Budget Bureau No. 99—5128
Approval Expires June 30, 1955

A National Study of High School Students and Their Plans

This questionnaire is made up of two parts: first, a short test of words and arithmetic, and, second, a number of questions about you and what you are interested in doing when you graduate from high school. The results will be used to make plans so that more high school graduates can be given opportunities to do the things they want to do.

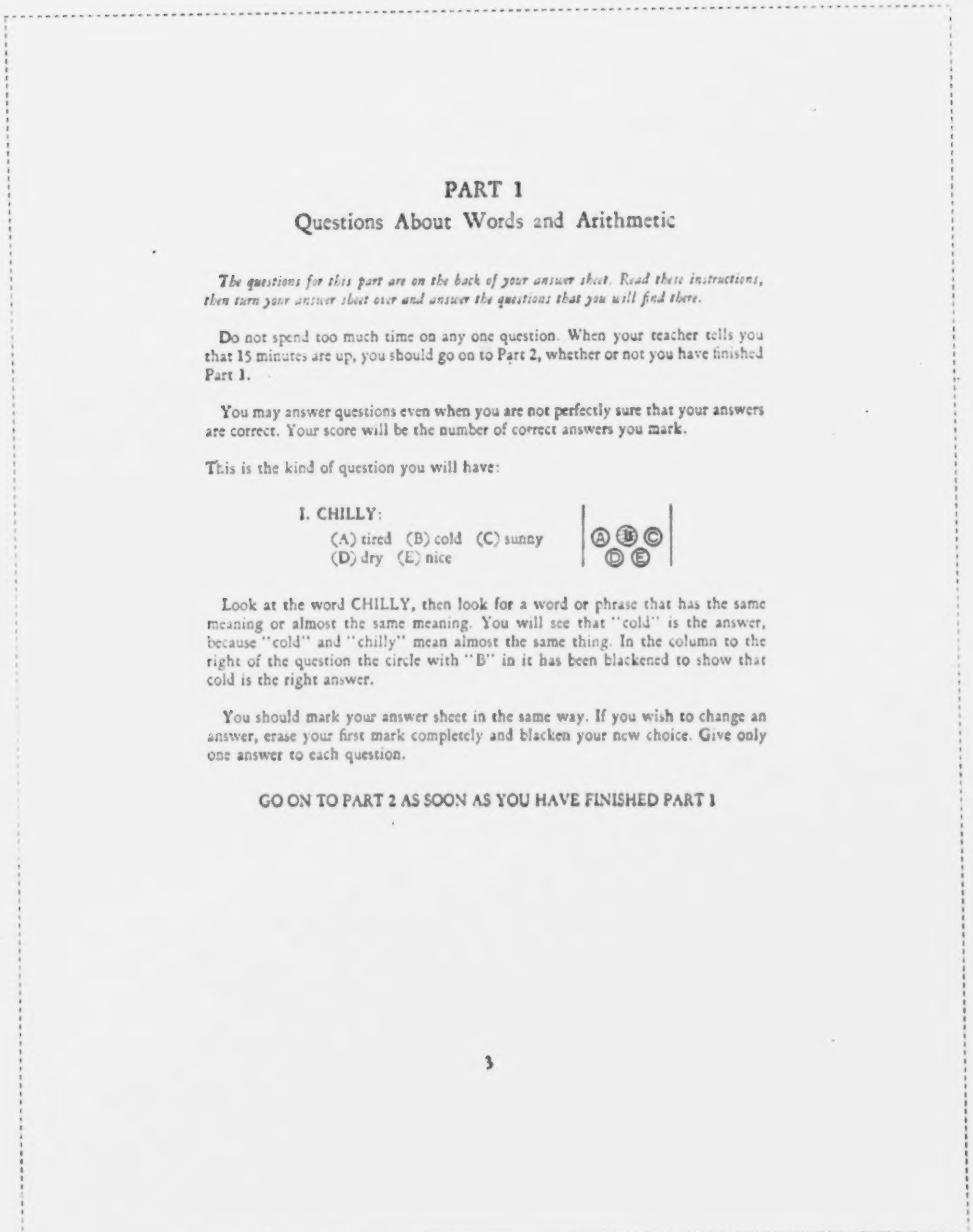
The way the students in your high school answer these questions will be compared with the answers from other high school students in all forty-eight states.

You may sometimes be asked about things that you have never thought about before. When you come to such a question, don't spend too much time, but think about it for a moment, then check the things that seem to fit you best.

Do *not* put your answers in this booklet. You are to mark your answers to all questions on the separate answer sheet which you have been given.

As soon as you have finished reading this page, fill in your name and the name and address of your school on the answer sheet, then go on to the next page. Read the directions, then start right in on the questions. Most students will have time to answer all the questions by the end of the class period.

EDUCATIONAL
TESTING SERVICE
PRINCETON, NEW JERSEY



PART 1

Questions About Words and Arithmetic

The questions for this part are on the back of your answer sheet. Read these instructions, then turn your answer sheet over and answer the questions that you will find there.

Do not spend too much time on any one question. When your teacher tells you that 15 minutes are up, you should go on to Part 2, whether or not you have finished Part 1.

You may answer questions even when you are not perfectly sure that your answers are correct. Your score will be the number of correct answers you mark.

This is the kind of question you will have:

I. CHILLY:
(A) tired (B) cold (C) sunny
(D) dry (E) nice

Ⓐ 🅑 Ⓒ
Ⓓ Ⓔ

Look at the word CHILLY, then look for a word or phrase that has the same meaning or almost the same meaning. You will see that "cold" is the answer, because "cold" and "chilly" mean almost the same thing. In the column to the right of the question the circle with "B" in it has been blackened to show that cold is the right answer.

You should mark your answer sheet in the same way. If you wish to change an answer, erase your first mark completely and blacken your new choice. Give only one answer to each question.

GO ON TO PART 2 AS SOON AS YOU HAVE FINISHED PART 1

3

PART 2

Questions About You and Your Plans

Now turn over the answer sheet. Be sure your name and the other lines at the top are filled in.

From now on your questions will be in this booklet. There will be a number or a line on the answer sheet for each question in the booklet. For most questions you should draw a little circle around the number on the answer sheet which stands for the thing that best fits or describes you.

EXAMPLE:

II. Which of the following countries would you like most to visit next summer?

(1) Canada

(2) Brazil

(3) France

(4) Mexico

Sample

II. 1 2 ③ 4

The person who answered this question decided that he would rather visit France than any of the other three countries.

Once in a while you will write down your own answer, rather than choose an answer printed in the booklet. Always do this in the proper space on the answer sheet.

21. How many brothers and sisters do you have? (Circle the number on the answer sheet which tells how many you have.)

22. How many brothers and sisters do you have that are *older than you*? (Circle the number on the answer sheet which tells how many you have.)

23. How many older brothers and sisters do you have that are attending (or have attended) college? (Circle the number on the answer sheet.)

24. Are your parents living? (Circle the corresponding number on the answer sheet.)

(1) both living	(3) only father living
(2) only mother living	(4) neither living

25. a. What is your father's occupation? What does he do? Be as specific as you can; for example, operates milling machine, repairs jewelry, sells candy to retail stores, etc. (If he is dead, say what his occupation *was*.) (Put your answer on the answer sheet.)

b. For what kind of business or organization does he work? (For example, electric power company, state government, retail store, construction company, etc.) (Put your answer on the answer sheet.)

26. How much formal education did your father have? (Continue to use the answer sheet for your responses.)

(1) some grade school

(2) finished grade school

(3) some high school

(4) finished high school

(5) some college

(6) finished college

(7) attended graduate school or professional school after college

(8) do not know

27. What are the college plans of the friend you like most?

(1) definitely planning to go to college, or is already in college

(2) thinking about college and will probably go

(3) thinking about college, but will probably decide not to go

(4) not planning to go to college

(5) do not know

GO ON TO THE NEXT PAGE

28. Of the people your own age with whom you spend most of your free time, how many of them plan to go to college, or are already going to college?

(1) none (3) most of them
(2) only a few (4) all of them

29. How good, on the average, have your high school grades been?

(1) in the top quarter of your class
(2) in the second quarter of your class
(3) in the third quarter
(4) in the lowest quarter

30. Which of the following high school programs of study are you now in, or do you plan to go into?

(1) college preparatory (academic)
(2) commercial
(3) general
(4) vocational
(5) other (specify on answer sheet)

31. How many half-years (semesters) of mathematics will you have taken in grades 9, 10, 11, 12 by the time you graduate? (Include only the courses you have taken in algebra, geometry, trigonometry, and calculus. Circle the number on the answer sheet which tells how many.)

32. As compared with the number of half-years of mathematics you have just circled, would you have preferred to take

(1) less (2) about the same (3) more

33. How many half-years (semesters) of science will you have taken in grades 9, 10, 11, 12 by the time you graduate? (Include only the courses you have taken in biology, chemistry, and physics. Circle the number on the answer sheet.)

34. As compared with the number of half-years of science you have just circled; would you have preferred to take

(1) less (2) about the same (3) more

35. To what extent have you discussed going to college with the teachers or guidance counselors (advisors) in your school?

(1) not at all (2) some (3) quite a lot

36 To what extent have you discussed going to college with your parents (or guardians)?

(1) not at all (2) some (3) quite a lot

37. Think about what you would like to be 15 years from now. Suppose that with hard work you would be successful in whatever you choose. Indicate in the blank on the answer sheet what occupation you would choose to make your goal.

38. Think of what you would *really like* to do when you finish high school. What statement in the following list tells what you would most like to do if you had your own choice? Circle the number on the answer sheet.

(1) go to college
(2) work for a year or two and then go to college
(3) get a part-time job and go to college
(4) get a full-time job and go to college at night
(5) go to a trade school, or take special training
(6) get a job
(7) become an apprentice
(8) other (specify on answer sheet)

39. What do you think you *will* do when you finish high school? (Suppose you do not go into military service.) Circle the number on the answer sheet for the thing that you will probably do.

(1) go to college
(2) work for a year or two and then go to college
(3) get a part-time job and go to college
(4) get a full-time job and go to college at night
(5) go to a trade school, or take special training
(6) get a job
(7) become an apprentice
(8) other (specify on answer sheet)

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Suppose that you would get a scholarship to go to college if you agreed to study a particular subject. The scholarship would be large enough to make it possible for you to attend a good college and you would have no need to worry about earning any part of your expenses. *But to get the scholarship you would have to agree to major in (or emphasize) some particular subject.*

Circle the *one* number on the answer sheet for *each* question which tells how willing you would be to major in (emphasize) that subject.

For questions 40-49, the numbers mean the following:

(1) I would *certainly* accept a scholarship to study this subject

(2) I would *probably* accept a scholarship to study this subject

(3) I *might* accept a scholarship to study this subject

(4) I would *probably not* accept a scholarship to study this subject

(5) I would *certainly not* accept a scholarship to study this subject

40. Engineering

41. Physical sciences (for example, physics, chemistry, geology)

42. Biological sciences (for example, zoology, botany, physiology)

43. Social sciences (for example, sociology, anthropology, political science, economics)

44. Mathematics

45. Liberal arts (for example, languages, philosophy, literature, history)

46. Fine arts (for example, music, painting, ballet)

47. Business

48. Education

49. Agriculture

CHECK TO MAKE SURE YOU HAVE CIRCLED AN ANSWER FOR ALL TEN QUESTIONS ABOUT SCHOLARSHIPS

In questions 50-54 you will be asked to choose several things instead of just one thing. Sometimes you will be told how many things to choose, and sometimes this will be left up to you. In these questions you should circle the number on the answer sheet which stands for *each* thing that you choose.

In addition, some of the questions will ask you to blacken the circle which you make around one of your choices. This will show which is your first choice, or which is most important to you.

EXAMPLE:

III. Which of the following subjects were most interesting to you? Circle the numbers on the answer sheet for the *three* subjects you found of greatest interest, then blacken the circle for the *one* of these three which was most interesting of all.

(1) chemistry
(2) Latin
(3) shop
(4) physical education
(5) English
(6) typing
(7) agriculture
(8) band

Sample

III. ① 2 3 ❹ 5 6 7 ⑧

The person who filled in this sample said that he found 1, 4, and 8 (chemistry, physical education, and band) more interesting than the other subjects in the list, and that 4, physical education, was the most interesting of all.

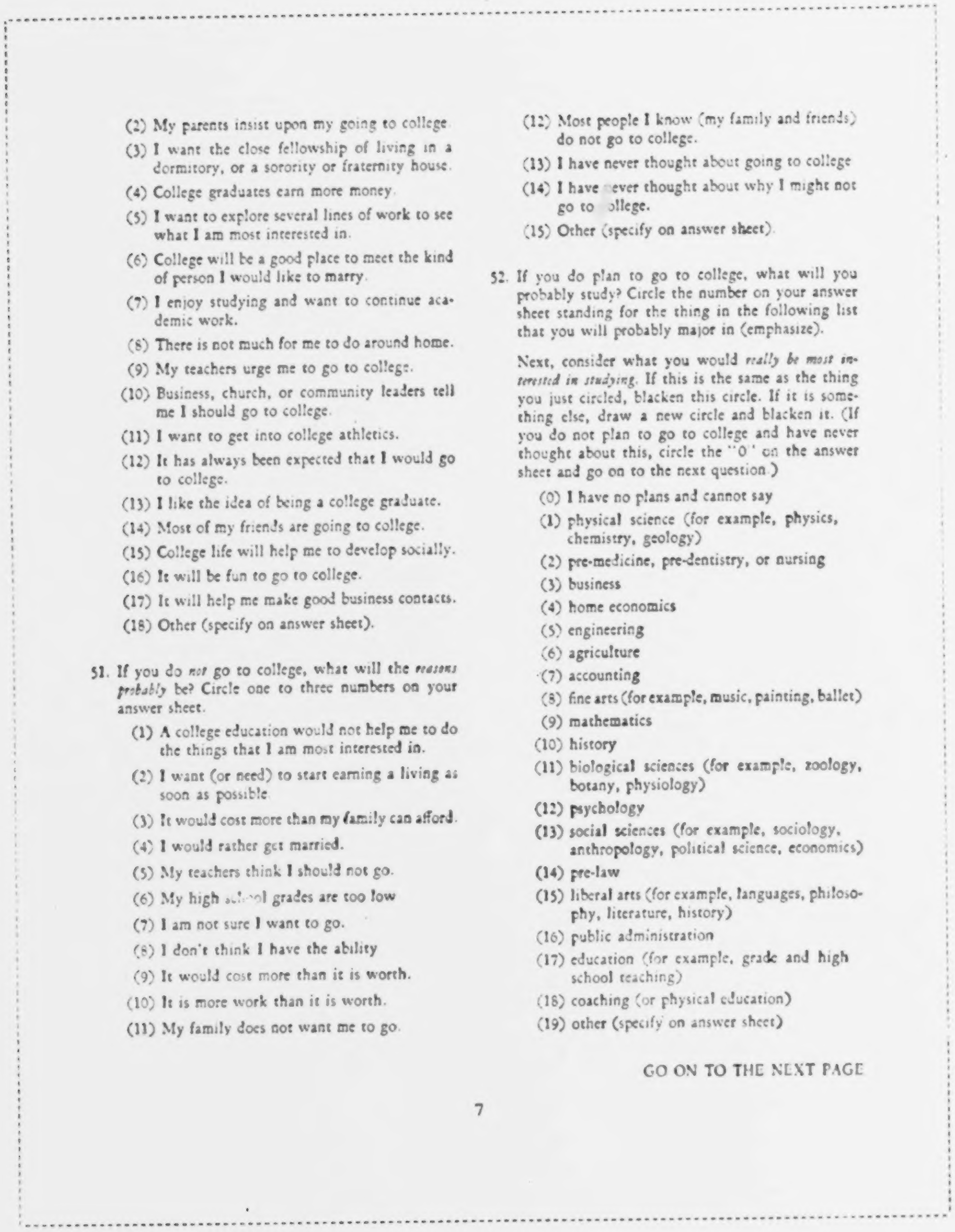
From here on it is especially important that you note carefully what you are to do for each question!

50. Why do you want to go to college? Circle the number on your answer sheet standing for each important reason. Blacken the circle for the one most important reason. (If you are not planning to go to college, circle the reasons that look good to you.)

(0) I do not want to go to college.

(1) A college degree is necessary for the kind of work I want to do.

GO ON TO THE NEXT PAGE



(2) My parents insist upon my going to college.
(3) I want the close fellowship of living in a dormitory, or a sorority or fraternity house.
(4) College graduates earn more money.
(5) I want to explore several lines of work to see what I am most interested in.
(6) College will be a good place to meet the kind of person I would like to marry.
(7) I enjoy studying and want to continue academic work.
(8) There is not much for me to do around home.
(9) My teachers urge me to go to college.
(10) Business, church, or community leaders tell me I should go to college.
(11) I want to get into college athletics.
(12) It has always been expected that I would go to college.
(13) I like the idea of being a college graduate.
(14) Most of my friends are going to college.
(15) College life will help me to develop socially.
(16) It will be fun to go to college.
(17) It will help me make good business contacts.
(18) Other (specify on answer sheet).

51. If you do *not* go to college, what will the *reasons probably* be? Circle one to three numbers on your answer sheet.
   (1) A college education would not help me to do the things that I am most interested in.
   (2) I want (or need) to start earning a living as soon as possible.
   (3) It would cost more than my family can afford.
   (4) I would rather get married.
   (5) My teachers think I should not go.
   (6) My high school grades are too low
   (7) I am not sure I want to go.
   (8) I don't think I have the ability
   (9) It would cost more than it is worth.
   (10) It is more work than it is worth.
   (11) My family does not want me to go.
   (12) Most people I know (my family and friends) do not go to college.
   (13) I have never thought about going to college
   (14) I have never thought about why I might not go to college.
   (15) Other (specify on answer sheet).

52. If you do plan to go to college, what will you probably study? Circle the number on your answer sheet standing for the thing in the following list that you will probably major in (emphasize).

   Next, consider what you would *really be most interested in studying*. If this is the same as the thing you just circled, blacken this circle. If it is something else, draw a new circle and blacken it. (If you do not plan to go to college and have never thought about this, circle the "0" on the answer sheet and go on to the next question.)
   (0) I have no plans and cannot say
   (1) physical science (for example, physics, chemistry, geology)
   (2) pre-medicine, pre-dentistry, or nursing
   (3) business
   (4) home economics
   (5) engineering
   (6) agriculture
   (7) accounting
   (8) fine arts (for example, music, painting, ballet)
   (9) mathematics
   (10) history
   (11) biological sciences (for example, zoology, botany, physiology)
   (12) psychology
   (13) social sciences (for example, sociology, anthropology, political science, economics)
   (14) pre-law
   (15) liberal arts (for example, languages, philosophy, literature, history)
   (16) public administration
   (17) education (for example, grade and high school teaching)
   (18) coaching (or physical education)
   (19) other (specify on answer sheet)

GO ON TO THE NEXT PAGE

53. What reasons will be important in deciding what college you will attend? Circle one to three numbers on the answer sheet. Blacken your circle for the most important reason. (If you do not plan to go to college, circle the "0" on the answer sheet and go on to the next question.)
    - (0) I do not plan to go
    - (1) athletic program
    - (2) cost
    - (3) family preference
    - (4) size of college
    - (5) nearness to home
    - (6) strong student employment program
    - (7) whether coeducational or not
    - (8) location in relation to other schools, big cities, climate, etc.
    - (9) academic reputation of the college
    - (10) excellence of training in field I am interested in
    - (11) religious reasons or affiliation
    - (12) students have a pleasant social life there
    - (13) the school will give me a scholarship
    - (14) I can meet the admission requirements
    - (15) the school's graduates can make good contacts
    - (16) my high school faculty recommend it
    - (17) my friends will go there
    - (18) other (specify on answer sheet)

54. Which of the following types of scholarship have you heard about? Circle on the answer sheet as many numbers as are needed to give your answer.
    - (1) Navy ROTC
    - (2) the Seven College Scholarship Program for Women
    - (3) Westinghouse Science Talent Search
    - (4) the national or regional scholarships offered by Harvard, Yale, or Princeton
    - (5) local industrial scholarships for which you are eligible
    - (6) scholarships offered by your state, your state university, or other colleges in your state
    - (7) any special scholarships available only to graduates of your high school
    - (8) have heard of none of the above
    - (9) other (specify on answer sheet)

If you plan to go to college, how do you think your college education will be paid for? (If you have no plans and cannot say, you may skip questions 55-59.)

> Answer questions 55-59 by circling the percentage on the answer sheet which most nearly shows what part of your college costs you think you will probably get from each of these five sources.

55. About what per cent do you expect your family or relatives to pay?

56. About what per cent do you expect your summer earnings and part-time jobs to pay?

57. About what per cent do you expect will be paid by a scholarship you hope to get?

58. About what per cent do you expect the government to pay (for example, through the ROTC, or by your attending West Point, Annapolis, etc.)?

59. About what per cent will you need to borrow?

If you finish before time is called, look over your answer sheet to be sure you have filled in the three lines at the top, then check to see that you have not forgotten anything. You may go back to the words and arithmetic if you wish.

Selective bibliography

This bibliography is intended for those who seek further and more detailed information on the subjects discussed in this work. It includes the books and articles that are cited in the text as well as many others, all of them arranged under general subject headings which do not correspond to the book's chapter titles. The bibliography subject divisions and the page numbers on which they begin are:

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The reader will note that in each subject division books have been listed first and periodicals second.

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